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OCCUPATIONAL ACCIDENT PREVENTION

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PREFACE

The need for a suitable textbook which would serve as a convenient and complete reference manual became apparent to us while conducting courses in industrial safety engineering. The material for the present book originated from instructors' notes prepared by us for these courses given under the Engineering, Science and Management War Training Program.

Every effort has been made to make the book complete and at the same time to eliminate all unnecessary detail. For example, a list of sound-slide films is included in place of illustrations.

This book will meet the needs of supervisory employees and foremen who are interested in industrial safety engineering; it is planned for the supervisory employee as well as for the safety director. It is not so much about safety itself as about the fundamentals in plant operation for bringing about accident prevention. Briefly, it is intended to show how to attain freedom from accidents.

Accidents may be prevented by controlling the personal defects in hazardous employment through job placement; they may be controlled by preventing unsafe acts through training to instill safe work habits; and they may be controlled by eliminating mechanical faults through proper and adequate guarding.

In preparing this book, the authors have attempted to record most of the means by which accidents have been controlled throughout industry in the past, so that this general knowledge may be available to all interested persons. For the solution of specific problems as they arise, the reader is referred to the Safe Practices Pamphlets of the National Safety Council, the safety codes of the American Standards Association, and the many excellent pamphlets prepared by the various branches of the United States Government. The information available from these sources could not be successfully condensed to fit any one book, nor would any reader wish so exhaustive a treatment of such a variety of subjects.

We wish to express our deep appreciation to the pioneers in safety work and to the many men who have devoted thought and effort to the development of accident prevention to its present status, where it is approaching the field of exact science.

Specifically, we wish to acknowledge with grateful appreciation the help of many students in the industrial safety engineering courses who assisted in the assembling of this material; of Major General Le R. Lutes, United States Army, in granting permission to publish material from the Warehouse Manual in the chapter on material handling; and of the American Standards Association, the National Safety Council, and the Illuminating Engineering Society for permission to reproduce pertinent information from their publications.

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1

INTRODUCTION

Leaders in government and private industries have estimated that 50 million workers are required to keep production at top levels. Annually the time of approximately 2 million of these is lost because of accidents on the job and at home. This is a loss of 4 per cent of the total man power required for production. Many injured persons are highly trained specialists and key men, the loss of whose services is even more serious than the percentage figures indicate.

Various large companies have conducted effective accident-prevention programs for many years, and their experience shows that the accident loss can be reduced to 1 per cent.

The federal government has recognized this fact, and many of its agencies are actively engaged in the promotion of accident prevention, particularly the United States Department of Labor and the United States Office of Education, which have assumed leadership in this field. The program adopted by these agencies has been based upon the experience of the larger companies, the most important phase of which is employee training, not specifically in safety, but in the best way to " do the job." This best way gives the greatest production because it achieves the greatest freedom from accidents and other interruptions in production.

Accident prevention is a joint problem of the federal government, state governments, insurance companies, management, labor, and other agencies. Under federal leadership, the interests of all these groups have been coordinated into spontaneous action. Two very important developments have been the training of thousands of foremen and other key personnel in industrial safety engineering through the leading engineering colleges of the country, and the training within industry of other thousands in foremanship. This training-within-industry program is being extended to train millions, rather than thousands. The effort is largely a pioneering one, for nothing approaching its magnitude has ever been attempted in this field.

While this training has developed considerably because of the man-power shortage, its benefits will be a permanent contribution to industry. The most important anticipated benefit is that small plants will be able to study the accident-prevention experience of the large companies and apply the lessons to their own problems. In volume of employees, the many small plants exceed the few large ones. Therefore, labor in general will profit immensely through the improved safety performance of the small plants.

The three sections of this book deal with three principal divisions of accident prevention: 1 improvement of work procedures, 2 improvement of plant and equipment, 3 and the safety organization and related activities. In actual application, it is not possible to separate and thus isolate the types, but their isolation for purposes of study is logical and helpful, and the following chapters have been arranged to conform to this plan.

The first step in evolving accident prevention is the development in management of a real and active interest. Management, in many cases, has failed to recognize the fact that effective accident prevention results in increased production, decreased production costs, and the elimination of production interruptions. Too often management feels that the term accident refers only to personal injury. Actually the damaging or destruction of a production machine is an accident of the first magnitude; the spoilage of valuable material in process can be an economic disaster. An accident may result in personal injury, damage to equipment, material spoilage, or any combination of these three. Accident prevention can eliminate many of the causes of all three types of losses.

Management must have not only an interest in accident prevention but also an ability to demonstrate that interest to the satisfaction of the supervisory staff and the rank-and-file employee. Management can effectively show this interest by the following.

1. Supervisory employees should insist on an accident-prevention attitude. This will require careful retraining of the present supervisory staff, as well as careful selection and training of new supervisors.

2. Physical hazards, wherever they may be found, should be analyzed and eliminated. Included in this phase are regular

inspections of plant, equipment, and processes; proper guarding of equipment; correction of processes; and provision of proper appliances and protective devices for the work.

3. Management should accept responsibility for the actions of every employee. The average employee acts as he feels the boss wishes him to act. Wrong behavior on his part means that he has not been convinced of the owner's desire that he behave properly.

Management must learn and accept the concept which is evident to the accident-prevention specialist: most accidents are the result of supervisory failure.

A necessary first step in installing an accident-prevention program, and one which clearly demonstrates the management's interest, is the setting up of an accident-prevention organization. The organization need not be elaborate but must be effective. Its primary purpose is to secure and maintain, first, the complete cooperation of all supervisory employees, and later, the combined efforts of all employees. It should be under the control of some properly designated, responsible person.

Management, having set up the organization and started it functioning, must keep it functioning. That is, it must give it the same attention and support it would give any other activity of the plant.

It has been demonstrated that poorly conceived and inadequately performed safety programs can be a great expense with little return. The accident-prevention movement has been blamed for many such fiascos. On the other hand, it has also been demonstrated that a proper approach to the problem, with intelligent planning and execution of essential measures, can produce effective results with little or no added expense. The time and money put into intelligent accident prevention is repaid many times over in operating economies.

There are three solutions to the problems usually encountered in the practical application of accident prevention to the operation of a plant.

1. Make the best of the existing plant, by improving work procedures, training and placing plant personnel, and generally cleaning up and putting the premises in order. This is primarily a function of the operating supervisory staff, aided by the safety-engineering group as consultants.

2. Improve plant and equipment, by guarding, redesign of

layout, acquisition of better facilities, protection against fires, and elimination of hazards. These are obviously functions of plant management, in which the safety-engineering group acts in the dual role of adviser to management and champion of the operating group in their effort to secure better working conditions.

3. Organize the safety-engineering group, its functions, and its allied activities, such as first aid; and organize the considered purchase of proper equipment for the protection of workers. These are administrative functions which are generally delegated to the safety director, who is required, with executive support, to obtain the necessary cooperation from the operating and staff groups within the plant.

2

IMPROVEMENT OF WORK PROCEDURES

CHAPTER I

Plant Housekeeping

In the design of an industrial plant, the architect is required to plan for the storage of raw materials, materials in process, and finished goods. Provision is made for tables, benches, chests, racks, and similar storage spaces for the tools which, from time to time, are required in production. Aisle space is planned so that persons and materials can move through the plant in a safe and orderly fashion. Proper illumination and proper hygienic conditions are provided. All of these things must be incorporated in the original design; yet the original design cannot insure that they will be present in the plant at all times. Despite the adequacy of storage space, stored materials may become untidy or unsafe if insufficient care is given to their placement. Lighting fixtures that are adequate for good illumination lose a considerable part of their efficiency if they become dirty or if the bulbs in them burn out and are not replaced. Marked off aisles which are blocked by miscellaneous items are not safe routes for industrial trucks; nor are oil-spotted aisles safe for pedestrian traffic. Every first-class feature that is set up through intelligent design can be destroyed by negligence on the part of the plant personnel.

The problem of keeping everything in its place and within its proper bounds is covered by the general subject of plant housekeeping, which can be defined as the care, custody, and maintenance of plant and equipment. Housekeeping must be a continuous activity, incorporated into the normal working processes of the organization, if it is to be successful and effective. It is often said that the condition of housekeeping within a plant is the most obvious indication (and one of the best) of the accident-prevention sincerity of the plant management and personnel, and an excellent indication of plant efficiency as well.

In many cases plant housekeeping is considered to imply only an occasional general cleanup of all debris, misplaced tools, improperly piled materials, and all other items of poor housekeeping. The cleanup has its part in the industrial program, just as spring cleaning has its part in the domestic housekeeping program. But, just as spring cleaning does not keep a house clean through fifty-two weeks of the year, so also the big cleanup, whether done annually or monthly, does not keep the plant in good housekeeping condition during normal operations.

Housekeeping functions are necessary adjuncts to production in any plant, but they often suffer neglect because they are not considered productive and are looked upon, possibly, as luxurious or wasteful. Coupled with this attitude is the fact that most housekeeping tasks are simple acts which skilled workmen consider beneath their dignity. Consequently a condition arises in which management begrudges the time and labor begrudges the effort necessary in good housekeeping. In such cases, a poor housekeeping condition naturally results and is permitted to continue.

Actually, no reduction in production expense can be made by tolerating poor housekeeping; if anything, an increase can be traced to this source. Because of their very nature, the individual conditions which make for poor housekeeping must be corrected eventually. Their correction can be deferred but cannot be avoided. The cost of the correction must be borne at some time, and the inconvenience caused by the conditions, while they exist, unavoidably causes additional expense. The following are some of the poor housekeeping faults most commonly found in plant operation.

Disposal of Waste and Scrap. In every industrial process a certain amount of waste or scrap is produced. In most cases a very large part of the goods that enter the plant as raw material will leave it as scrap. In some cases the scrap output outweighs the finished product. In the simple operation of turning square stock down to round shapes, 21.5 per cent of the raw material is removed and either scrapped or wasted.

Naturally scrap material cannot be permitted to accumulate for long periods or it would fill the available walking and working space and would generally hamper operations. The problem is: will the scrap or waste be removed in an orderly and efficient manner, or will it be allowed to accumulate until it becomes intolerable to the machine operator? Frequently this means: will the scrap be removed by an efficient mechanical means which is inexpensive to operate, by a porter, or by the highly paid machinist who is forced, because of accumulated scrap materials, to stop his normal operations to do porter work?

Plant management can well afford to investigate the continuous automatic removal of scrap and waste. Often considerable economy in operation will result from eliminating the hidden cost of manual disposal. This is almost always the case where machines are in operation continuously, or nearly so. As an example, modern power stations use a water sluice to remove coal ash from boiler pits to settling tanks. By this means the cost of handling ash is reduced to so small an amount that the ash can be sold at a considerable net profit, often more than enough to pay the entire labor and power cost of handling the coal and ash within the station.

When an automatic system is not considered justified, simple devices can frequently be built to deposit the scrap or waste in suitable containers by the action of gravity, or under the impulse of the initial velocity of the scrap particles as they leave the operation. Such containers can be changed by an efficient porter service frequently enough to prevent their overflowing or spilling, and thus eliminate the poor housekeeping condition at its source.

Nails Left in Wood. Whenever wood construction is demolished, or wooden boxes or crates opened and broken up, a potential hazard of nail puncture wounds is present. If the nails are allowed to remain in the wood, unflattened, this potential hazard becomes very real. Every piece of wood in which nails are left is dangerous because someone may tread upon it and become injured.

There is only one circumstance under which nails in wood do not require treatment. Nails in the wood obviously do not constitute hazards if the wood is to be incinerated and if the dismantling operation is conducted immediately adjacent to the incinerator, or if suitable mechanical means for immediate transportation to an incinerator are provided. The scrap wood and nails are eliminated as rapidly as they are freed, and an excellent condition of housekeeping is obtained. Under these conditions the only handling of the nail-studded wood is in the initial dismantling operation which is unavoidable and which can be done with reasonable safety. Wood stripped from construction or crating is usually either salvaged as reused lumber, burned as fuel, or incinerated.

If the wood is to be salvaged, the nails must be withdrawn before reuse. The labor to withdraw such nails will be expended eventually; no saving results from permitting the nails to remain in the wood even for a short time. If salvage is intended, a greater recovery of usable wood will result if a nail puller is used in dismantling instead of a ripping bar, and the overall labor cost of dismantling the construction and removing the nails is less with this arrangement than with ripping technique.

If, as is often the case, scrap wood is made available to persons outside the plant for their private use, the plant risks the chance of a lawsuit in the event that a person scavenging it is injured by a nail, especially if that person is a child. Further, if a nail-studded board drops from a scavenger's wagon and punctures an automobile tire, legal responsibility would probably rest with the plant. In self-protection, any wood released for such use should be nail-free or at least should have all nails bent flat.

If scrap wood is to be used for fuel within the plant, the presence of nails in it may jam automatic ash-removal gears or mechanically operated grates. Where this possibility exists, in order that boiler maintenance may not become excessive, the nails must be withdrawn before the wood is fed to the fire. (Of course, if the boiler and its accessories are proof against such interference, the conditions amount to approximately those of incineration, which will be discussed later.) Where interference exists, the removal of the nails just before burning will require more labor than would be necessary if they had been removed at the time of dismantling, and the inconvenience because of the delay resulting from the removal will probably be greater at this point in the cycle. Permitting the hazard to exist increases operating costs even if accidents are avoided by unusual care.

If wood is to be incinerated eventually, or is to be used as fuel in boilers unaffected by nails, it probably will be collected in piles and allowed to accumulate for some time before it is burned. In such cases, if nails are left standing, they add considerably to the bulk of the pile and to the annoyance resulting from their presence. The handling of such wood consumes excessive time because care is needed to avoid injury and because standing nails often hook into other boards and cause the board in which they are embedded to become entangled and jammed. Because of these considerations, a net saving in labor cost results if, at the outset, all nails are bent flat.

Thus it can be seen that, in every case in which reusable or scrap wood is produced, the nails in the wood should be either removed or flattened in the initial operation. The choice between removal or flattening of the nails will, as indicated, depend upon whether the wood is to be scrapped or salvaged, and, if scrapped, in what manner. As a matter of good operating technique the decision as to the ultimate disposal of the wood should be made before dismantling, the appropriate decision as to removal or flattening of nails should be made at that point, and the flattening or removal operation should be incorporated in the initial dismantling job. In this way the risk of foot or hand injuries from nails can be completely eliminated without increasing in any way the net operating costs. Probably these costs will be found to be decreased.

Illumination. Lighting bulbs and fixtures lose a considerable part of their efficiency if they are permitted to become dirty, since the dirt film will absorb some of the light rays and convert them to useless heat. It is not unusual to find as much as one-third of the total illumination in a plant destroyed and wasted in this manner. This loss is a proportionate part of the lighting bill.

It has been demonstrated that it is economic, in almost all cases, to clean bulbs and fixtures whenever the light output decreases to 75 per cent of the output when new and clean. In the few other cases, where the location is extremely dirty, it is economic to provide initial illumination in excess of the amount required and to permit a heavier dirt accumulation. (It is not necessary to test the illumination repeatedly since a proper periodic maintenance program can be established on the basis of a few tests.)

As will be pointed out in a later chapter, every electrical-maintenance operation should be performed with the circuit dead. When cleaning permanent lighting fixtures, the circuit should be switched off; portable lighting fixtures should be disconnected at the plug before cleaning. As added precautions against shock, the worker should stand on a wooden ladder and should use dry cloths.

Bulbs that burn out and are not replaced destroy the designed balance of the lighting system. If a room has four fixtures providing light that is ample and of good quality, the darkening of one fixture will cut down the illumination by one quarter and will almost completely destroy the quality of the remaining light. Sharply outlined shadows are produced in the darkened corner, and the remaining light sources become glaring when viewed from that corner. Thus the loss of one fixture results in a creation of shadows and glare, both of which are detrimental characteristics of poor lighting. In a room served by a larger number of lighting units, the loss of one fixture will not usually produce glare and shadow, but it will noticeably reduce the illumination in the immediate neighborhood of the fixture. This condition accelerates fatigue among employees required to work in the area and reduces their efficiency.

It may be said that, if an electric bulb has burned out, a certain small saving results, due to the decreased consumption of electrical energy. The fallacy in such a consideration is that, while the bulb itself is burned out, the investment represented by the fixture and wiring which served this bulb is not productive and therefore is temporarily wasted. Of course, if the burned-out bulb is not required to maintain a good level and quality of illumination, the system is improperly designed and the installation in itself is wasteful.

Burned-out bulbs should be replaced as soon as possible to reestablish normal lighting conditions and worker efficiency. The fact that the decreased illumination may create an accident hazard is an added consideration that should not be needed to justify prompt replacement.

Oil on Floors, Platforms, or Stairs. Oil and greases are used in plants for many purposes, some of the most common uses being lubrication, cutting operations, and the cooling of electrical equipment. Because of their wide-spread use, it is not difficult to understand that drops of oil or blobs of grease occasionally are found on the plant floors, platforms, stair surfaces, and other walking areas.

Oils generally have several harmful characteristics if improperly controlled. They are, in themselves, flammable under proper conditions. Impregnated into fibrous material, such as wood or cloth, oils make these materials highly combustible. Rubber in contact with oil will deteriorate rapidly; drops of oil can damage or destroy the insulation of portable equipment lead wires and of the permanent wiring in conduits beneath the floor. Finally, drops of oil cause the floor surfaces to become slippery.

Oil and grease drippings should, if possible, be eliminated at their source. Common sources of these nuisances are: careless handling of grease guns, or of oil in transit; careless filling of oil cans or grease guns; over-filling of oil reservoirs, oil cups, or grease cups on machines; lack of proper drip pans or other collection devices where oil spillage is unavoidable and anticipated; defective machinery, leaking oil, or grease at bearings or gear boxes. The cure in each case is obvious. The first three items require care on the part of employees, and in turn require proper, adequate, and positive instruction of the employees by their supervisors. The fourth requires improvement in design of the equipment, and the fifth requires machine maintenance.

Every employee should be instructed to wipe up oil or grease found on the floor as soon as it is noticed, regardless of its source, and to call the attention of his foreman or supervisor to the condition so that the underlying fault can be corrected.

Oily Waste and Oily Work Clothing. Oily waste thrown into out-of-the-way corners, or into unsuitable containers, or left in work clothes which are later dropped into lockers, readily starts fires through spontaneous ignition. Similarly oil- and grease-spattered work clothing dumped in a pile on a locker floor constitutes a spontaneous ignition risk.

The potential loss from spontaneous ignition of oily waste or clothes is primarily property damage rather than personal injury, but the underlying cause is a poor housekeeping condition. Elimination of this danger involves three simple precautions of which only the last may entail any considerable expense. These are:

1. Provide special containers for the disposal of oily waste, which should be emptied at least once on each shift.
2. Instruct employees to dispose of such waste promptly rather than leave it in work clothing. Also instruct employees to hang their work clothes in the locker rather than drop them on the locker floor.
3. Encourage washing of work clothes; possibly provide plant laundry service for this purpose.

The degree of effectiveness of this means of prevention depends upon employee cooperation to some extent. In some plants where the potential loss resulting from fire is great, special locker equipment is provided to minimize this risk. Frequently a two-compartment locker is provided for each worker so that one compartment may be used for work clothes and the other for clean clothes. In addition, a ventilation system is built around the lockers so that air is blown through a duct system at the top and exhausted through ventilating louvres at the bottom of the locker doors. Air circulation of this nature almost completely eliminates the risk of spontaneous ignition.

Conclusion. A number of common housekeeping faults have been discussed above. Many others could, of course, be added. The examples cited are typical. From them certain general conclusions can be drawn that are applicable to every other poor housekeeping condition. 1. Housekeeping faults are, in general, conditions which require menial or unskilled action for correction; hence they are often considered by workmen as beneath their dignity. 2. Every housekeeping fault must sooner or later be corrected because of operating necessity. Correction can be postponed but it cannot be avoided. 3. Correction at the outset is generally less expensive than delayed correction. 4. Accidents are frequently caused by poor housekeeping, but good housekeeping is an operating staff responsibility, not an accident-prevention function.

Housekeeping is a field in which safe working requires merely that the job be done in the proper way rather than by slip-shod, inefficient methods. In estimating the housekeeping condition of a plant, proper weight must be given to the consideration of whether or not the proper facilities have been provided to make good housekeeping possible. This means that a place must be provided for everything before insisting upon everything being kept or put in its place.

CHAPTER II

Handling Materials

The substitution of mechanical power for manual handling of material is a long step toward accident prevention. Through the medium of job analysis or any other method, a complete survey should be made of all manual handling operations. Those repeated most frequently should be considered first for substitution by a satisfactory mechanical means of accomplishing the same purpose. Frequently the substitution of mechanical equipment can be done at such a low cost that tremendous savings accrue. The labor thus released from this work can be made available for other more important activities. In addition, proper planning and the adoption of suitable procedures often reduce or minimize the need for handling materials.

FLOW OF MATERIAL

In the original design of the plant, careful consideration should be given to receiving the raw material, the arrangement in the warehouse or storeroom, the flow of materials during the process in operation, and ultimately the storage and shipment of the finished product. Changes that take place subsequent to the original design, such as an increase in the plant capacity or a change in the product itself, make the material-handling problem difficult. The design should be of such a nature that excessive handling of materials is avoided.

WAREHOUSE OR STOREROOM

Consideration should be given first to the kind of material or property to be handled, the length of the haul, and the time the property will be stored. Next select the type of equipment most efficient for handling the particular material concerned, taking every factor into consideration together with the availability of the equipment. Then consider the selection and training of a well-balanced crew for the operation of the equipment.

Many warehouse accidents and much lost time can be avoided by carefully planning the work before it is undertaken. All materials received should be definitely scheduled, the storage place and equipment selected, and the men thoroughly instructed before the job is started. Where sprinkler systems are installed, care should be taken not to pile material within eighteen inches of the sprinkler head. Special precautions should be taken against smoking and other fire hazards.

TYPES OF EQUIPMENT

The main types of handling equipment used in the operation of a warehouse are: two-wheel hand trucks, four-wheel platform trucks, three-wheel and four-wheel tractors together with four-wheel trailers with couplers, either automatic or hand, platform lift trucks in conjunction with legged skids, fork lift trucks in conjunction with dunnage or pallets, single and double-faced, power conveyors, horizontal and incline, and portable power elevators. Supplemental to this equipment are the gravity conveyors, both roller and skate type, hand jack platform lift trucks, hand fork type lift trucks and dollies. In addition to these main essential types of equipment there are several kinds of special equipment, such as cranes, rams, monorails, chain hoists, etc., to handle extra large and heavy types of property. To assist the supervisor in determining the most suitable type of mechanical equipment to use, a brief description of those generally used, together with suggestions for their application, follows.

Two-Wheel Hand Trucks. Hand trucks may be of various designs, each type intended primarily for transporting specific types of material but adaptable to other uses. They are used for transporting rapidly a few items per load short distances. Their use is not recommended for hauls of more than 100 feet.

Four-Wheel Hand Trucks. Four-wheel hand trucks are equipped with platforms on which property can be manually piled for transporting. Their advantage over two-wheel trucks is in the amount of property carried per trip. They are used to advantage for assembling material but should be restricted to short-distance movement.

Trailers. Trailers are usually of 4,000 pounds capacity with 3 feet by 6 feet platforms, and equipped with automatic couplers permitting them to be used in trains towed by a tractor for long distance hauls. For short hauls when power equipment is not available, they can be used the same as four-wheel hand trucks.

Tractors. Tractors are used for towing trains of trailers on long hauls. They are either the three-wheel type, which is particularly adaptable for inside operation, since its short turning radius permits it to maneuver in narrow aisles and congested areas, or the larger four-wheel type used for outdoor work. By coupling from six to ten trailers to a train towed by a tractor, greater tonnage can be moved long distances. The length of the haul should be governed by the efficiency achieved. Tractor-trailer trains used to supplement fork truck operations prove indispensable since they eliminate the necessity for many extra trips by the fork truck between carrier and stack.

Trucks. Probably the most important item of material-handling equipment is the fork truck. Its popularity is due to adaptability to meet specific handling problems encountered in unloading, transporting, stacking, and shipping. Fork trucks are built with various capacities and maximum fork heights. Fork trucks are of two types: central control, with the driver positioned near the uprights, or rear control, with the driver standing on a platform at the rear. In the center control type the driver's weight has little effect upon the capacity, but in the rear control type for safe practice care must be taken that the operator does not step from the platform when tiering capacity loads as the load and machine could be easily upset. This is particularly true when using light machines with 144 inches maximum lift for tiering pallet loads.

Conveyors. Conveyors are of two types: power and gravity. Power-driven conveyors are usually of the belt type, but in some instances the load-carrying surface of the conveyor may be composed of wooden slats supported by chains. Conveyors are obtainable in various lengths and are restricted to certain specific operations. Gravity conveyors have the load-carrying surface made either with rollers of various widths and diameters or an arrangement of roller skate wheels. Choice of either arrangement is determined by the commodity to be handled. The roller skate conveyor is adapted for handling uniform packages with smooth sides or bottoms, whereas the roller type can be adapted to odd-shaped packages.

Stackers. Stackers are essentially portable, vertical elevators, and are made in both hinge type and telescopic type. They are usually equipped with a platform for manually piling the material, and can be obtained in various capacities and lifting heights. They are limited in use, and, as they require a power unit when used in stacking operations, they are not recommended except in congested areas where lift trucks will not operate.

Cranes. There are two types of cranes commonly used — a small industrial type crane used indoors for handling small objects. These cranes are equipped with either a full slewing boom for loading trailers or a half slewing boom for loading a platform on the front of the crane truck. Outdoor cranes are heavier and are wheel or crawler equipped, with long booms, either telescopic or non-telescopic, capable of unloading and piling large, bulky, or very heavy material. They are essential for all outdoor operations.

Supplemental Equipment. Supplemental equipment, such as pallet trucks, dollies, chain hoists, etc., are used to supplement the other mechanical equipment, and are used for certain specific movements of material during unloading or storing operations. Such equipment should be obtained and used to assure full utilization of the other mechanical equipment.

USE OF EQUIPMENT

Mechanical equipment should be used wherever possible. In selecting the type of equipment, consideration must be given to the kind of material to be handled. For example, case goods can frequently be stacked on pallets in the freight car and then moved on fork lift trucks directly to the stack for storing, without any further manual handling. When long hauls cannot be avoided, it is better to place the pallet on trailer trucks, which can then be hauled in trains to the storage location for stacking by fork equipment. When cars and trucks cannot be entered by the mechanical equipment used, short lengths of roller conveyors may be used from the car to the point on the platform where the pallets can be loaded. This method must usually be resorted to if refrigerator cars with floor racks have been used.

Multiple Loading. As a general rule multiple loading, that is, any method which picks up and handles two or more packages at a time, is superior to handling each case or package singly. When the carrier brings in shipments containing assorted sizes or mixed types of material it is advisable to sort as near the point of unloading as possible. The sorted packages can then be made into units, and either stacked on pallets or handled directly, as units, by fork trucks. In all such operations, every effort should be made to minimize the number of handlings. Freight should flow directly and continuously from the carrier to the ultimate stack in the warehouse. The manual labor should be distributed so as to equalize the work, both at the carrier and at the stacks; time should not be lost by either men or equipment by waiting for some part of the operation to catch up; such bottle-necks should be constantly watched for and eliminated. All interruptions in the flow of material from carrier to stack must be avoided.

Balance of Man Power and Equipment. In the use of any equipment the assigning of man power in balance with the equipment to be used is most essential. For example, if the Supervisor has only two-wheel hand trucks available, the labor crew that is assigned to unload the car should be divided in balance. Two men should be placed in the car to build stacks for transporting by the two-wheel hand trucks from the car to the stack. One or two men at the stack are sufficient when the stack is first started. As the stack develops in height and it is necessary to pile higher than a man can normally reach, additional men must be assigned. If a portable elevator is available, this equipment is helpful to convey the material to the upper levels of the stack. Hand trucks should be assigned in sufficient number only to keep the car labor and the stack labor working at a steady pace. The number of hand trucks assigned varies according to the length of haul. This same principle applies in the use of four-wheel flat trucks. The two-wheel or the four-wheel flat truck method of unloading cars normally would take seven to ten men. . . .

The purpose of power equipment is to save man power, and modern handling equipment such as fork trucks will cut the crew for unloading a car from the minimum of seven down to a minimum of three, two of which will be loading the pallets in the flat car and the third driving the fork truck. The fork truck would place the empty pallets in the car for unloading and would in turn take the loaded pallets from the car and accomplish stacking the entire pile without the help of any additional men. But here again the balance of men and equipment is essential to develop the highest efficiency. Occasionally two extra men assigned to work in the freight car, making a five-man crew, will be needed to keep the fork truck working continually; however, the number of men in the crew depends on the length of haul from the freight car to the stack. If the length of haul is over 150 feet, it is advisable to use tractors and trailers for the purpose of transporting the pallets of property from the freight car to the stack, and to use the fork trucks merely for the purpose of stacking the material.

Use of Fork Trucks. Fork trucks have tremendous flexibility. New uses for them will continue to be developed. They can be used to advantage on most types of material if the proper study is given to the number of fingers on the fork, its length, and the spacing between fingers. At present they are used for handling and warehousing material in several different ways, three of which are:

1. Material that is packed in large containers can be handled by using dunnage of the proper length and depth — that is to say, no longer than the depth of the unit load in direct contact with the fingers of the fork truck. The dunnage spaces the units vertically so that the fingers of the fork truck can get between them conveniently.

2. Material that is packed in small containers and has sufficiently high compression strength can be handled with the use of a single-faced pallet with dunnage. The single-faced pallet is used on such material as kegs of nails, pails of paint, and any other type of property which is packed in a container sufficiently strong to stand the pressure of the dunnage resting directly on it.

3. Material that is packed in small containers with low compression strength should be handled in conjunction with a double-faced pallet. This type of pallet protects the crushing of containers by spreading the weight of the load over a large area rather than concentrating it on a relatively small area.

Use of Tractors and Trailers. The use of tractors and trailers has been mentioned in conjunction with power lift equipment. This type of equipment is also very valuable for use when power lift equipment is not available. The trailers are used for unloading and loading in the same method as described for four-wheel flat trucks or the two-wheel hand trucks, but can be used in cases of long hauls (that is, over 150 feet) by coupling them together and pulling them by means of a power tractor.

Conveyor Equipment. Conveyor equipment, both power and gravity, when available can be used for the purpose of transporting the merchandise from the car to stack in place of any rolling equipment. Conveyors are very advantageous in some operations where inspection, labeling, or packing is necessary. Conveyors are used in conjunction with man power, and the balance of man power assignment with the equipment is essential to get efficient operation. Conveyors which are used for the conveying of property horizontally can be hooked up at the stack with inclined power conveyors for the purpose of stacking some types of property, such as bags and small, strongly constructed containers and cases containing nonbreakable merchandise. Conveyors, as a steady and sole type of handling equipment, are not desirable. They are not flexible, and while in use they temporarily block the aisle for any other use. Conveyor equipment, however, is most valuable in conjunction with other types of power equipment, such as fork trucks. They can be used in this connection for moving the material from freight cars to the platform when the power lift equipment is of such size that it cannot enter the freight car. They can also be used to advantage in loading or unloading motor trucks.

Cranes. Cranes are used mostly in outside storage for the purpose of unloading material packed in large heavy cases or crates, and for piling this material. They are also used for handling raw materials such as steel in all forms and also any other large, bulky, or very heavy objects, such as tanks, guns, and a wide variety of engineering equipment. In using cranes for unloading and piling material of this type, it is essential that the freight car be placed as closely to the point of storage as possible and the crane be moved in a position so that it can pick up the material in the freight car by means of its boom and swing it to the position of storage without actually moving the crane itself. Where it is necessary to store further back from the freight car than the crane boom can actually reach, it is desirable sometimes to have another crane working in conjunction with the crane that is actually unloading the material from the freight car. This is done by the unloading crane placing the material on the ground as near as possible to the point of storage, and the other crane picking it up and actually piling it. If the point of storage is of even greater distance than will allow this type of operation the use of motor truck equipment is necessary to transport the material from the position of the unloading crane to the position of the piling crane.

1. In the use of this type of equipment the balance of men with the equipment is again essential. It is usually necessary to have two men in the freight car adjusting the slings or grab hooks, on the material to be moved, and at the point of piling, two men for the purpose of freeing the slings or grab hooks after the material is placed in final position.

2. There is usually one extra man to act as a guide for the crane operator. The assigning of the number of men to any piece of handling equipment is a matter of judgment and it is the fine art of operating that makes for the efficient or inefficient operation. The capable supervisor will so assign his men that the mechanical equipment is operating 100 per cent of the time, and it is the *pacemaker for all of the men in the crew.*

CARE OF EQUIPMENT

Mechanical equipment can function properly only if it is well cared for. Since this equipment is vital to the efficiency of the handling operations, the supervisor should see that a well-equipped maintenance department is established to furnish frequent systematic inspection of the equipment and keep it properly lubricated and repaired.

Most manufacturers of mechanical equipment furnish lubrication charts and repair manuals with the equipment. If they are not available, efforts should be made to obtain them. The charts specify the proper grade of lubricants to be used on the various parts, and these instructions should be adhered to.

It is advisable to have each piece of equipment numbered and a record kept of the inspections, lubrications, and repairs. In this way the Supervisor can periodically check up on the efficiency of the maintenance department and see that the equipment receives proper attention, anticipate repairs and replacement and have sufficient parts available to make immediate repairs on minor breakdowns. Every hour the equipment is out of service is costly. Idle equipment is not helping to handle materials. Machine time is as valuable as man-hours. Keep them working.

LABOR

SUPERVISION

The control of employees assigned to material-handling work is one of the most important duties of the Supervisor. This work actually comes more directly under one of his assistants, but the Supervisor must administer, organize and see that his plans are carried out. Man power assigned to an operation should balance the machine equipment. Neither should have to wait for the other at any time. No two operations are exactly alike, and it is the duty of the supervisor to watch each operation constantly and see that neither too many nor too few men are on the job. It should be remembered that one extra man is quite likely to interfere with the work of the others, and that ordinarily the most efficient and safest operation is a little shortage of man power rather than a little over-all. Because of this, it is better to assign just a few men to a job and then add others if necessary, rather than to assign a large gang and try to withdraw those who are not needed. It is the duty of all personnel in a supervisory capacity to instruct and train the individuals under them in team work and skill. The well-trained man will do twice as much work with half the effort as a clumsy man.

MAINTENANCE OF MORALE

A factor that should be given constant consideration is the morale and spirit of the workmen. Their grievances should be weighed seriously. Every effort should be made to eliminate all inconveniences. Wherever possible, the men should be told why they are performing certain functions and the need for speed; and when extra effort is called for, the reason therefor should be explained. The competitive spirit is invaluable. Pride in work well done should be developed in everyone, as men work more easily and are less tired when they work well.

MISCELLANEOUS

WAREHOUSES

Warehouses should always be kept neat and clean. Nothing breaks down morale quicker than working in a sloppy warehouse; however, common sense must be used. Time spent in precision aligning of stock is not productive. The package should be placed in the pile carefully the first time so there is no necessity for hammering it to push it into this line.

SHIPPING

The physical methods of handling the material in making a shipment are approximately the reverse of the inbound movement. The same basic rules apply. Material should, whenever possible, move directly from stock to carrier without interruption or rehandling. However, it is sometimes necessary to assemble various types of material to be shipped together. In this type of operation, the rehandling of packages should be avoided wherever possible. If it is necessary to mark packages, this function should be performed at stack or carrier, whichever is more practical. In shipping, choice of handling equipment is very important. On large lots of material the same methods as used in the inbound movement can be utilized. On small lots it is very often necessary to manhandle the material trailers, which can be assembled and handled in trains to the carrier in cases of long hauls.

USE OF FREIGHT CARS

Whenever freight cars are used for shipping, they should be loaded to the maximum, if possible, and the standard loading and bracing rules put out by the railroads should be followed. Explanatory booklets can be obtained from the Association of American Railroads, Washington, D. C. They contain much useful information concerning inspection, cleaning, bracing, closing, and sealing freight cars. A copy of the manifest should always be tacked in the freight car before it is sealed.*

ACCIDENT-PREVENTION MEASURES

Since handling of materials and equipment is one of the major sources of injuries, some of the preventive measures which may be used are provision of: proper clearances between sidings and between tracks and fixed structures; adequate gates, warning signals and signs; adequate yard lighting for night operations.

The transportation of materials through the plant should be provided for by adequate aisle space clearly marked, and by the thorough training of the operators of all power vehicles, hand trucks, etc.

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* Extracts from the *Warehouse Manual,* U. S. Army, by special permission.

The manual handling of articles and materials during the production process frequently results in minor injuries. These may be prevented by the use of gloves, wrist and hand aprons, safety shoes, goggles, safety clothing, and other similar protective equipment. All employees should be thoroughly trained in the proper manner of lifting and should have a knowledge of the special handing methods best suited to the specific conditions involved.

Fresh-air helmets should be worn by all employees entering tank cars because of the hazard of suffocation or poisoning. In addition there is an explosion hazard; therefore cars should not be entered until they have been thoroughly steamed out and ventilated.

Material in storage should be piled so that there is no possibility of its falling. This may be caused by change of the nature of material due to the increased pressure or weight, or to inadequate tying in with other material. As an example, paraffin wax, when piled too high, will melt at the bottom thereby permitting the pile to fall.*

The handling of acids, caustics, and other hazardous substances may result in burns, dermatoses, eye injuries, and the inhalation of toxic fumes. Such injuries should be protected against by special equipment for handling these substances, the use of personal protective equipment, and the use of specially trained men. It may be desirable to transfer to other work certain individuals who are allergic to some of the materials.

Poor maintenance of equipment, floors, and buildings is another potential cause of accident in handling materials. As an example, defective floors may cause material to fall from truck or trailer. Defective material-handling equipment may cause an accident through loss of control, failure of parts, or failure of the limit switch to operate. Many of these conditions are discussed in Chapter III, Maintenance Problems.

Handling material on a remodeling job is somewhat more difficult and hazardous than on a new building, partly because of the simultaneous demolition, but chiefly because the available working space is likely to be limited. Congestion is the cause of many material-handling accidents and is most prominent in this type of work. To insure safe working conditions, the demolition or construction activities should be segregated from the regular operations and provision made for the rapid removal of debris.

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* The Safe Practices Pamphlets and Safety Instruction Cards give many examples and illustrations of the proper methods of piling and unpiling materials.

The careful scheduling of delivery of material in such a way as to minimize the need for storage, and the use of storage space or storehouse outside of the active construction area, should be considered.

REFERENCES

Special Bull. 11, U. S. Department of Labor, Division of Standards.
A.S.A. Standard Code Cranes, Derricks, and Hoists, 1943.
Lifting Heavy Weights in Defense Industries, Special Bull. 2, U. S. Department of Labor, Women's Bureau.

CHAPTER III

Maintenance Problems

Maintenance may be defined as the effort expended to keep the plant equipment and buildings in good operating condition and available for production. It may be preventive or corrective in character. Preventive maintenance, as applied to a machine, implies frequent inspection to detect minor faults and early correction of such faults as they are found, supplemented by periodic overhauling of the machine on such a schedule that the possibility of the occurrence of a major breakdown is almost completely eliminated. Corrective maintenance means simply the correction of faults after they have become obvious, and gives no assurance that a major breakdown will not occur.

In most plants, both types of maintenance are used. A major defect in one of the plant buildings, or in a vital machine, would seriously reduce or completely stop production. The plant buildings and vital machines are therefore placed on a preventive maintenance schedule. Other machines, which are not as vital to production, are repaired only when damage has occurred to them. Since breakdowns of machines frequently cause severe injuries to their operators, the safety director generally prefers to have as much maintenance work as possible performed in a preventive rather than corrective manner.

Scheduling of Preventive Maintenance. Where several machines of the same type are in operation, records should be kept of the hours in operation, or such other data as will measure wear. This information, correlated with records of past failures, will serve as a guide in scheduling preventive repairs before failures occur. In this way the chance of extensive machine damage may be minimized and the possibility of personal injuries almost eliminated.

Original Design Incorporating Provisions for Safe Maintenance Work. The original design of the plant buildings and equipment should provide for safe performance of maintenance work by allowing adequate space for dismantling machines, by providing eye bolts and hangers for lifting heavy pieces of equipment, by providing window cleaners' bolts on all windows above the street level, and by many similar items which must be built into both the buildings and equipment.

Man Power for Maintenance. There are three general methods of providing man power for the performance of maintenance work. Plant employees can be used on maintenance at times when they are not required for production work, a maintenance crew can be employed to work solely in this field, or an outside party can be engaged on a contract basis to perform the maintenance work. As each of these alternatives gives rise to conditions which, if not controlled, may result in personal injury accidents, it is the responsibility of the safety director to assure that proper and adequate controls are established to eliminate these conditions. In almost every plant all of these methods will be used; therefore each one deserves detailed consideration as to the accident problems presented and the available means of control.

Use of Operating Personnel in Performing Maintenance Work. The basis for employing, in maintenance work, operating personnel who would otherwise be idle, lies in two facts: morale is higher when persons are busy, and some value can thus be derived in return for the wages which must in any case be paid.

The prime accident hazard arising in this situation is the risk that persons may be detailed to unfamiliar work which in all probability will prove to be beyond their individual skills. The use of unfamiliar tools, lack of skill in handling heavy machine parts, and lack of knowledge of the internal parts of the machines afford ample opportunity for both personal-injury accidents and damage to the machines.

Effective control can be exerted to eliminate these hazards by limiting the scope of the maintenance work which may be undertaken by operating personnel to jobs which are known to be within their skill and knowledge and those which an average person can reasonably be anticipated to be capable of performing. To establish and exert this control will require that the safety director, in cooperation with the operating supervisory group, carefully study the maintenance jobs most frequently required and determine which can and which cannot be performed with safety by operating personnel. The hazardous maintenance work should be done by maintenance crews or outside contractors.

In some plants it is necessary to have a number of extra employees available for emergencies or as substitutes for absentees. In such cases it is usually desirable to unite these employees to form a maintenance crew and to draw persons from this crew as required to meet emergency or absentee situations.

Maintenance Crew. A maintenance crew consists of a number of persons individually and collectively trained in the skills required for maintenance work. Such a crew operates under a maintenance foreman and is not subject to control by the production foremen, but it may be so constituted as to cooperate effectively in production functions under emergency conditions. The establishing of a maintenance crew is the best and most effective method of providing man power for maintenance jobs which are periodically performed. A well-trained maintenance crew can do such work with great economy and freedom from accidents.

The principal hazards found in the use of a maintenance crew arise from such conditions as inadequacy of maintenance tools and equipment and possible conflict of authority between production foremen and the maintenance foreman. The control of the first of these requires that the maintenance crew be equipped with proper and adequate tools and equipment for the work which they normally do, and that any unusual jobs which require special tools be let on contract to outside parties properly equipped to perform them.

To prevent conflict between production and maintenance groups, it is necessary that the line of authority be sharply drawn to eliminate the points which may cause conflict. As a specific instance, a hold-off system should be instituted providing that when a machine has been turned over to the maintenance crew for maintenance or repair, it is not to be operated until the required work has been completed. The hold-off system should also provide that when operation of a near-by machine will expose the maintenance crew to the risk of injury, the maintenance foreman may require that this machine also be shut down until completion of the maintenance work.

Maintenance by Contractors. Large and unusual maintenance tasks are commonly let on contract to outside parties. Whenever third parties are brought into a plant, a mutual accident risk is unavoidably created by their unfamiliarity with the plant operations and by the interference with operating functions which results from their presence.

The only satisfactory control of the third party hazard applicable to maintenance work on contract is effective segregation of the maintenance job from normal plant operations. All machines in the vicinity of the maintenance job should be shut down, with their power supply cut off by switches or mechanical controls locked in the open position. Except for necessary inspections, operating personnel should be excluded, by suitable barricading, from the area in which the contractor is to work. (In many cases it is found desirable to erect temporary partitions around this area.) Employees of the contractor should not be permitted to walk through other parts of the plant except for such travel as is necessary to gain access to work area or to toilets. This necessary travel should be closely supervised to prevent wandering.

Poor Maintenance versus Good Maintenance. In cases of poor maintenance or where maintenance is neglected, the accident rate of the plant may be expected to be high; conversely, where good maintenance prevails, the accident record is generally low. Since maintenance is a non-productive activity, it is difficult to give a definite positive value to good maintenance. However, management must reach a decision as to the size and scope of the maintenance program to be undertaken and, to do so, must estimate its value. Occasionally, too ambitious a program is undertaken, resulting in waste through excessive cleaning and polishing and sometimes through needless removal of equipment from service.

Generally the maintenance is less than the minimum required for uninterrupted operation. With insufficient preventive maintenance, it may reasonably be anticipated (and it usually is so found) that minor defects will appear at the time when the machines are being used to their fullest capacity. At such times it is often considered impossible to shut down even for minor repairs; in consequence the defective equipment is continued in service until breakdown. The breakdown of a machine frequently produces accidental personal injuries. Such injuries are likely to prove severe and costly.

The direct cost of deferred maintenance will obviously exceed the direct cost of preventive maintenance on the same machine, at least by the cost of the breakdown. But since preventive maintenance covers all machines and since deferred maintenance only touches those which actually become defective, the total direct cost of the former will greatly exceed that of the latter. However, in the case of the deferred maintenance, high indirect costs are experienced, resulting from loss of production at critical periods, lost time of full production crews during emergency repairs, and other large but hidden items. If all the contributing factors are considered, it will usually be concluded that a firm engaged in competition cannot afford to defer maintenance.

Inspections. Many instances of need for maintenance are disclosed by inspection. For this reason, recommendations of safety inspectors (or others) regarding maintenance should be given very careful attention. Operators of equipment should be considered potential inspectors and should be instructed to report any indications of impending machine failure so that maintenance may be effected before a breakdown. Inspections may be supplemented by special tests, as, for instance, the measurement of insulation resistance on electrical equipment. Such tests are applied as an integral part of the inspection plan.

Many types of equipment require periodic inspection, test, and maintenance. In this group are elevators, pressure vessels, cranes, slings, extension cords, and portable electric devices. In many cases inspections are required by law or by insurance carriers. The elevator inspection is so thorough and accurate that it alone is sufficient certification of the good condition of the elevator, and interim inspections are not necessary between those required by law. On the other hand, the insurance inspection of pressure vessels is accurate and complete only in so far as certifying the equipment to be mechanically sound. This inspection must be supplemented by repeated service inspections to check conditions of use and by continuous small maintenance, such as the drainage of condensate from air receivers. It is important that every required inspection be properly evaluated, and, if need exists, it should be supplemented by interim inspections and maintenance to insure safe operation.

Supervision and Training of the Maintenance Crew. The maintenance crew should be composed of thoroughly experienced men capable of meeting emergencies and of working independently or as a team. Obviously very few such men are available, and it is necessary to train specially those who have the potential qualifications. This training can best be given through instruction by the maintenance supervisor and actual experience on the job while working under the guidance of seasoned men. Failure to assign capable men to assume the responsibility for good maintenance often results in personal injury and damage to property and equipment during maintenance operations.

Maintenance methods are extremely important from the safety standpoint because the safety of the maintenance crew and of the operating personnel depends upon the thoroughness with which maintenance work is conducted.

Safety Equipment. There are many items of safety equipment that apply specifically to maintenance men, including practically all personal protective devices normally used by the operating personnel, and other equipment, such as safety belts used by window cleaners and safety body harness with life lines used on scaffolding and other operations.

Leather or fibre safety belts should be purchased according to carefully prepared specifications. Leather belts, if properly maintained, will last longer and are more flexible and consequently more comfortable. However, they require a good deal of care and therefore should be frequently inspected by persons familiar with the treatment of leather. The internal qualities of leather vary so widely that the strength of one new belt is not indicative of the strength of others of similar cost and design, and the belts cannot be individually tested because the test destroys them.

On the other hand, fibre belts are unusually consistent in strength tests so that the testing of one or several belts will certify to the quality of the entire shipment. Although the life of a fibre belt is shorter than that of a leather belt, the fibre belt on inspection will show wear long before actual failure. For this reason, fibre belts are frequently preferred to leather.

Safety harnesses for men working on scaffolds and in similar risks are required by law in many states. In all such operations, attachment lines should normally be slack to permit work and movement. To avoid severe bodily injury resulting from a fall, a shock-absorbing mechanism, such as the parachute harness, should be used in every such application. Where belts or harnesses are not considered practical or where they interfere with operations, life nets can be provided beneath the place of work.

Metal fittings on safety belts and harnesses should be forgings, properly heat treated and annealed. Castings are unsatisfactory in this use because of the possibility of sand holes in the material, or of other undetectible flaws.

Safety belts and harnesses should be very carefully inspected by competent persons before their original acceptance. They should be inspected by the wearer each time they are used. They should be inspected regularly, at least every three months, by a competent inspector. Men required to wear safety belts should be thoroughly instructed as to their use, inspection, and importance of proper care of them when not in use.

Building Maintenance. Building maintenance in itself involves many specific accident hazards; furthermore, a condition of inadequate or improper maintenance may create or increase operational hazards. For example, window cleaning is a hazardous task which may be made more or less hazardous by the care taken in providing for it in the original design. On the other hand, to avoid operational hazards, window cleaners' attachment bolts should be periodically tested for strength as an accident-prevention maintenance procedure. A simple lever test device, which can be constructed, will safely apply to the bolt a stress greater than that resulting from a window cleaner's fall with only one belt-end attached, the condition under which the bolt would be most severely loaded in use. Any "give" in the bolt will be made apparent by deflection of the lever beam and will indicate that the bolt should be replaced.

Unsuitable floor wax, or improperly applied floor wax, can produce serious slipping hazards. Before floor wax is purchased, a sample should be laboratory tested to assure that it affords adequate friction (or grip) in contact with normal shoe and overshoe materials under all anticipated conditions, both wet and dry. Wax should be applied sparingly, using the minimum amount required to preserve and beautify the floor surface. Failure to repair floor covering, broken floor surfaces, or worn stair treads permits the growth and continuance of tripping and falling hazards.

Wooden furniture, too, may be a hazard. If not properly maintained, it will cause splinter accidents and possible infections.

Thus, in building maintenance, the accident preventionist has two problems: first, to see that building maintenance is done in a safe manner and, second, to be sure it is done in such a way that safe working conditions are provided.

Temporary Repairs. As a matter of general policy it is advisable to avoid temporary repairs, although in some cases it may be necessary to sanction them. Their chief dangers are that they are frequently done in makeshift fashion and that they are too often neglected so that the final and complete job is not done.

Where a temporary repair is permitted, it must be performed in a substantial manner, and the final repair must be done as soon as possible thereafter. In no case should a temporary repair be permitted on equipment that may endanger life, such as ladders or scaffolding, guards, and electric wiring.

Conclusions. Maintenance entails a considerably higher degree of responsibility than is usually realized. This responsibility should be given only to a well-qualified, capable individual. All maintenance work should be planned and a schedule prepared so that each specific job will be handled in a routine manner without requiring emergency measures or makeshifts. The planning should include provision of all necessary materials, devices, and equipment to perform the contemplated job. The complete cooperation of all the supervisory employees is necessary in order to report and schedule the need for maintenance on equipment far enough in advance to perform the work in an orderly fashion and without interruption to production. An adequate supply of all the necessary personal protective equipment should be provided for men assigned to maintenance work. These men should be fully trained and backed up by the best supervision available.

CHAPTER IV

Prevention of Falls

Statistics. Each year in the United States approximately 26,000 persons lose their lives as a result of falls; this figure is equally divided between male and female. One-fourth of the total number of fatalities occurs in industry, while one-half occurs in the home. Falls are the second highest in the list of compensated injuries. They comprise 23 per cent of the total compensation paid and 18 per cent of all accidents occurring in industry.

Falls are predominantly a hazard of old age, and the total population in the older age groups has been increasing. Falls make up 60 per cent of all accidental deaths among persons of 65 years and over, and 22 per cent of the accidental deaths in the age group of 45 to 64. In the younger age groups, the percentage is less than 10.

The seasons of the year and other weather factors have very little effect upon the number of people injured by falls. The fatalities, for example, run very close to average (about 2,150 each month) throughout the entire year.

A report prepared by the New York State Department of Labor for a typical month, in which 119 fatal accidents were reported, comments as follows.

> Twenty-nine of the industrial deaths reported during March were the result of injuries caused by falls from elevated places and on the ground level. Falls from elevations included five from platforms, two from scaffolds, two from structures being erected, one from a roof and one from a ladder. Five men and one woman were victims of falls down stairways. A window cleaner slipped and fell from a sixth floor window. A construction worker walking across a plank fell into a ditch and struck his head, resulting in a concussion of the brain. A material checker was drowned when he slipped on an icy pier and fell into the water. Falls while they were at work on the ground level took the lives of eight men and one woman.

It is unfortunate that information is relatively scarce regarding falls and their prevention. Accident statistics have not been analyzed in sufficient detail to give specific aid in planning a falls-prevention program. This may be due in part to the relative simplicity of most accident causes which result in falls. The types of dangers that precipitate falls are of such a common variety that they are frequently overlooked or not given the attention they should receive.

Stairs. In the original design of buildings, conditions are often encountered which tend to prevent the installation of suitable stairs but which can be overcome in many instances. Every effort should be made to avoid winding stairs or stairs that require the use of a triangular-shaped tread. The best design for an all-purpose stair employs 7-inch risers, 11-inch treads, and 1-inch nosings. The width should be not less than 36 inches nor more than 88 inches between hand rails. Any stair of three risers or more should have at least one hand rail. Hand rails should be not less than 30 inches nor more than 34 inches from the upper surface of the top rail to the surface of the tread, in line with the face of the riser at the forward edge of the tread. Anti-slip stair treads are recommended for all-purpose stairs. The vertical rise of a single flight of steps should be limited to 10 feet. If the total rise exceeds this amount, it should be broken into several flights with landings provided where necessary to achieve this condition. Landings should be at least 3 feet 6 inches wide.

Stairways should be well lighted to avoid shadows and possible blacked-out areas. In industrial plants, stair-tread nosings are frequently highlighted by colored paint in contrast to the remainder of the tread surfaces, in order to improve visibility.

Maintenance and the correction of defects in stairs are very essential. Some of the common defects are risers of unequal heights, risers omitted on inside stairs, stair treads of unequal widths, split or uneven treads, treads too narrow, treads slippery or sloping outward, no nosing, loose or missing hand rail, lack of hand clearance between rail and wall, stairs too steep, inadequate or improper lighting, no toeboards on stair landings, stair flights too long, stair landings too narrow, and stairs cluttered with refuse or stored material.

Supervision and training are also factors in the prevention of stair accidents. It may be possible to change the working hours to a staggered schedule in order to avoid overcrowding. Instruction in the proper method of using stairs (particularly when carrying materials), using hand rails, and wearing of proper shoes and clothing, is also essential.

Ladders. The Safety Code for Construction, Care and Use of Ladders No. A14-1935 should be considered as a minimum requirement for the purchase of ladders. All ladders should be purchased unpainted so that the grain and condition of the wood can be carefully inspected. After a ladder has been inspected and accepted, it should receive a protective coating of either pure spar varnish or special moisture-proof protection. Ladders should be purchased in accordance with specifications so that the most suitable type will be selected for safe performance of the work.

A fixed ladder is always preferable to a portable ladder. Special attention should be given to this item in order that the use of portable ladders may be kept at a minimum. A well-designed fixed ladder will have rungs spaced on 12-inch centers, approximately 18 inches between side rails, and clearance at the back of the ladder not less than 6½ inches at any point. The side rails should extend to a safe point above the floor, roof, or platform, and should be goose-necked or otherwise arranged to give hand holds at least 42 inches above the floor level. A cage 24 inches wide and 20 inches deep, starting 7 feet from the base of the ladder, should be provided on all ladders over 20 feet in vertical height.

Common defects found on fixed ladders are uneven rung spacing; bent, loose, or missing rungs; lack of toe clearance at back of ladder; loose ladders; lack of hand holds at the top of the ladder; ladders sloping outward at the top; slippery rungs and rails; lack of cages on high ladders; in ladders made of wood, cross-grained, weak, or poorly constructed side rails or rungs.

Supervision and training are equally important to insure safe use of ladders. Supervisory employees should be alert to detect any defective condition which renders a ladder hazardous. Regular inspections should be made of all ladders, at least every six months. Any ladder found defective should be withdrawn from service immediately and replaced, or the ladder should be repaired by a competent ladder repairman. Temporary repairs on ladders should never be permitted. Since the average employee does not know how to use a ladder safely, the supervisor or foreman should see that men are properly instructed in their use and that instructions are followed. Ladders are frequently damaged by improper handling, particularly when being lowered to the ground. They should never be permitted to fall or be given a severe shock. Ladders should be protected from the weather as much as possible. In storage, they should be hung on pegs of about 8-foot centers indoors. However, if this is not possible, they may be stored in a vertical position, provided they are properly secured to the wall by chain fasteners.

Methods of Securing Ladders in Use. Portable ladders must be prevented from moving or shifting while in use. This can be accomplished in several ways that vary in effectiveness. The safest is the fastening of the top of the ladder, which prevents the ladder from slipping or sliding in any direction. Tying the bottom of a ladder prevents the feet from sliding away from the wall but does not prevent accidents from over-reaching, from ladder feet sinking, or from other similar conditions. One person holding the bottom of the ladder, while another climbs it, provides almost complete protection against movement of the ladder feet and against passers-by striking and upsetting the ladder, but it does not eliminate the over-reaching type of accident.

Safety feet provide a limited protection against ladder shifts and are valuable in preventing splintering of the ladder side rails. Safety feet must be well maintained, with shoes properly suited for the surface upon which they rest. When flat-surface safety feet are used, they should be cleaned regularly.

Of the three devices above described, top-tying is limited to places where anchor spots are available and to tasks which take considerable time or which require heavy exertion. Bottom-tying is used where only one man is available, where anchors for top-tying are not available, or where the ladder jobs require only short periods of time. Holding of the bottom of the ladder is advisable at heavy traffic areas (in passageways, or outside buildings near doors) or where the ladder-top tasks are of such short duration as to make this more economic than bottom-tying.

Scaffolds. Many states have enacted legislation covering temporary elevated work platforms because of the high degree of hazard involved. The law of the state of New York, which is typical, requires that

> all scaffolding or staging more than twenty feet from the ground or floor, swung or suspending from an overhead support, or erected with stationary supports except scaffolding within the interior of the building and covering the entire floor space of any room therein, shall have a safety rail of suitable

material properly attached, bolted, or otherwise secured. The safety rail should be at least thirty four inches above the floor or main portion of such scaffoldings or stagings, extending along the entire length of the outside and the end thereof, with only such openings as may be necessary for the delivery of materials. Such scaffolding or staging shall be so fastened as to prevent it from swaying from the building or structure. All scaffolding shall be so constructed as to bear the weight of four times the maximum weight required to be placed thereon when in use.

In addition to good original design, scaffolding must be well maintained and closely supervised while in use. Patented scaffolding (using metal pipes with suitable clamps or fixtures) has proven very satisfactory and very flexible. Where this material is available, its use is recommended.

When scaffolds are supported by manila or hemp rope, such rope should be of excellent quality, carefully and frequently inspected, tubbed* while in use, and stored under ideal conditions. There are many ways in which rope can deteriorate without noticeable signs of weakness. Where rope is exposed to acid fumes, moisture, and other contaminants, it deteriorates very rapidly and may fail while in use, resulting in the loss of a life. Therefore scaffold rope should be given very careful inspection before each use and replaced promptly when deterioration is detected.

Life lines attached to workmen's belts and to the building structure are sometimes provided independent of the scaffolding ropes. However, this may prove hazardous if the scaffold should fall because of the impact given the workman's body when the slack in a life line is suddenly used up. If the line from a permanent structure is attached to the person by means of a belt around his abdomen, a severe, if not fatal, injury may be inflicted. Therefore, wherever life lines are used, a complete parachute-harness attachment should be provided. The use of an elastic ring in the life line (which may be attached without cutting the rope by leaving a loop of line between points of tying) provides an excellent cushion to minimize shock in the event of a fall. Life lines attached to the hand rail of the scaffold are of value in preventing persons falling from a scaffold. However, they are of no value in preventing falls in the event of failure of all the scaffold ropes.

* Tubbed, as used here, means coiled in tubs or barrels to protect the rope from animals, or other sources of injury.

Scaffold planks should be carefully inspected for knots or other defects, particularly where the maximum bending moment occurs. They should never be tested in such a way as to weaken them, as by overloading or impact. Scaffold planks should be specifically marked for that purpose in order to avoid mixing them with other equipment. Ladders should never be used as scaffold planking.

Ramps. The enlarging of plants or extension into other buildings often brings about the need for ramps where floor levels are not on the same plane. The design of a ramp from the safety standpoint is very important, for a ramp almost invariably introduces some form of hazard. It is practically impossible to design a ramp which does not have some hazards associated with it.

The angle of incline or slope of a ramp should be kept as small as possible. In some states a legal limit has been established of 1 foot rise in 10 feet of length. In any case the ramp should be provided with hand railings 42 inches in height and should comply with the American Standard Safety Code for Floor and Wall Openings and Railings.

Ramps made with granolithic or cement surfaces should be rough finished, or abrasive material should be inserted in the cement. Ramps used in construction work where heavy vehicles or wheel barrows are used should be provided with cross cleats about every 11 inches to prevent slipping. Permanent ramps in buildings should be so constructed as to contrast with floor surfacing and thus attract attention; distinctive painting, and running ramp planks contrary to floor planks, are devices commonly used to obtain this result.

Falls on Level Surfaces. About one half of the fall injuries in industry occur on level surfaces. The severity, however, is considerably less than from falls from elevated areas. The most common cause of falls on level surfaces is a slippery condition caused by oil, grease, water, soap, improper wax, or other materials on the floor surfaces. To prevent this hazard, splash guards and drip pans should be provided wherever oil or grease drips are anticipated. Regular and systematic maintenance with good housekeeping is essential. Where spillage of chemicals or other materials is a problem, the methods or devices used for handling such materials should be investigated.

There are many floor waxes on the market that are distinctly hazardous. On the other hand there are waxes available which are designed and advertised as anti-slipping waxes. The available waxes should be tested to determine the actual slipping hazard in each; under normal, dry conditions; spotted with drops of water, as from umbrella drips; and thoroughly wetted, as for cleaning. The method of application of wax should be thoroughly studied, and the amount of wax should be limited to the quantity required to prevent wearing of the floor surfacing.

The coefficient of friction of adjacent floor surfaces should not change too abruptly, as in the case of smooth floor plates or worn metal door saddles next to concrete flooring. The floor surface may be painted in various colors to indicate hazardous areas around machines or other equipment.

Extension cords, telephone connections, hose lines, piping, or conduits that run above the floor level introduce tripping hazards. These defectively designed conditions should be corrected by relocation.

Inadequate lighting is frequently a factor in falls. This may be due to insufficient or improper light or to lighting units not properly maintained. Illumination should be of a type that avoids glare. If steam, vapor, or other conditions that might introduce shadows or otherwise impair illumination can be expected in a plant, they should be considered in the lighting design. Clean, light walls and ceilings are a factor in reflecting light. Floor openings and stairs should be adequately illuminated; in addition, contrasting colors can be used to attract attention to the position of the steps or openings. Most of the electric light and power companies are prepared to furnish, without cost, the services of trained illuminating engineers to assist their customers in the correction of illuminating faults. The safety director should use such facilities freely.

The tile floors of shower stalls and locker rooms often present a hazard because of the slipperiness that results from soap residue. Rubber mats are not desirable and may contribute to the spread of athlete's foot. Abrasive tile, however, is far more satisfactory, minimizing the slipping hazard without introducing any other hazards.

Men working out of doors during icy weather or sleet storms, if confined to a small working area, should have an adequate supply of sand or fine cinders to be used to improve footing. In larger working areas, the men should be furnished with ice creepers, metal devices attached to the under side of shoes to prevent slipping.

Conclusions. Falls are frequently the cause of serious, often fatal, injuries both in and out of industry. Falls consistently rank high in the list of causes of fatal accidents.

The prevention of falls from elevations requires proper and adequate supervision of the use of stairs, ladders, and scaffolds. Ladders and scaffolding materials should be frequently inspected. Ropes used with scaffolds or as life lines should be inspected before each use.

Falls on the same level can be controlled by giving proper attention to plant housekeeping, footing, and illumination.

CHAPTER V

Hand Tools

For accident-prevention purposes, the ideal arrangement is to have all processes mechanically performed. Man then becomes a supervisor of mechanical energy and is protected from accidental injury because the machine he operates is designed for safe operation and for prevention of unsafe action. In practice, however, a tremendous amount of manual work is still required. This involves the use of hand tools which often cause, or contribute to, accidents.

It should be pointed out that there are many manual operations performed today which could be performed more efficiently and with less expense if machinery were substituted. It is the responsibility of every supervisory employee and safety director to observe all manual operations performed in his plant and to substitute mechanical devices or machinery wherever possible and practicable. The National Safety Council Reports for 1942 show hand tools were responsible for 8.1 per cent of the compensated occupational accidents.

More than half of the accidental injuries from hand tools result from misuse of the tool. The corrective measures, as in many other instances, are training and supervision. Workmen should never be permitted to use tools for anything other than their designed purposes, and each tool should be suitable for the particular work for which it is to be used. A wrench should never be used as a hammer; a cold chisel or a file should never be used as a lever; nor should an open-end wrench which does not properly fit the nut be made to fit by any such makeshift expedient as a shim. A tool should be used only for the purpose for which it was designed, and then only in the manner intended. Thus an open-end wrench of good design will never spring unless abused either by hammering, by using with a pipe to increase leverage, or by using on only a part of a fitting.

PURCHASE OF TOOLS

Since many accidents are a direct result of tools which were of poor quality originally, it is important that only the best available tools be purchased.

Where tools are made or repaired in the plant, it is very important that the best and most suitable material be used. Too often inadequate specifications are given to purchasing agents with the result that inferior materials are bought. Tools made from inferior materials soon become defective and require a great amount of maintenance. The cost of the material itself is not an indication of its suitability; in some cases more expensive materials are not as desirable as less expensive ones. In the case of steel, where the proper alloy should be provided for each specific use, the storekeeper should segregate these materials and identify them for their proper use. A purchase specification should be prepared by which all tool steel and similar material should be purchased. The same general procedure should be employed in purchasing wooden handles and other wooden products used in tools. The wooden handles of all hand tools should be of the best straight-grained material, free from slivers, and preferably of hickory, ash, or maple.

If the services of a research department are available in the plant, it is desirable to consult it regarding the preferred materials and types of tools and to have it check purchases against specifications. When no such source of information is available, it is generally desirable to buy tools with a good brand name from dependable firms. These tools may be more expensive initially, but, in the long run, their economy is vastly superior to cheaper makes since their use results in fewer tool replacements, better workmanship, and fewer accidents.

DEFECTIVE TOOLS

In addition to poor initial quality of tools, there are many tools that may be considered defective because of faulty design or workmanship. As an example, a cold chisel, cutter, or punch head should be shaped accurately so that the end is at right angles to the center line of the tool and the corners rounded to a 3/16-inch radius. This permits a greater area of contact between the struck tool and the striking force, thereby permitting the tool to remain in service much longer without maintenance. Another example is the manner in which the handle of a hammer has been inserted and secured. Very few workmen know how to perform this task properly. Hammer handles that are too short or too long create defective tool conditions initially.

Many hand tools become defective from usage. The heads become mushroomed from being struck repeatedly. This is considered normal wear and is provided for, as previously explained, by the 3/16-inch radius bevel at the edge of the flat head. If mushrooming occurs too soon, it indicates that tools are improperly tempered. If the heat treating of the tool steel cannot be controlled in purchase, it is advisable to set up facilities in the plant shop to re-treat the tools properly both before and after use.

Mushroomed tools become hazardous as soon as the end material flows over the section of the shank. The condition becomes acute when radial cracks appear in the mushrooming. Grinding off the exuded material does not completely remove the hazard. The temper of the remaining steel has been destroyed; grinding does not correct this condition, with the result that mushrooming will soon recur. Flying particles, caused by excessive mushrooming, are a hazard not normally recognized. These particles gain as much momentum as a bullet shot from a gun and carry as much danger. They are frequently the cause of eye injuries and have been known to cause other serious damage.

In the design of a wrench the various parts are made of sufficient strength to carry the maximum force that may be normally applied at the end of the handle. When a greater force is applied, either by using a piece of pipe to increase the length of the handle, or by striking the end of the handle with a hammer, the various parts of the wrench are subjected to a strain far greater than that for which they were designed. Therefore, the wrench will fail and be strained to such a point that it is no longer safe to use. When a wrench is not properly fitted to the nut, or part, only a portion of the jaw surface is engaged, and this portion is so overstrained that it may readily fail by spreading.

INSPECTION AND MAINTENANCE

Pipe wrenches should be inspected regularly to see that the corrugations on the jaws are well sharpened and cleaned. The teeth should be neither cracked nor broken. The nut holder on a pipe wrench may easily cause an accident. It should be inspected to see that it is not cracked or broken, and missing springs should be immediately replaced. On chain tongs the link nearest the jaw is the one that usually fails first. This should be inspected frequently. When tong handles, through defective design or wear, reach the stage that they pinch the user's hands they should be reshaped to their proper condition.

Wood chisels should be provided with good strong handles. A metal band around the end of the handle will help it retain its shape indefinitely.

Since it is difficult and expensive to obtain good hand tools, there is a tendency to use them after their normal life has expired. As an example, a cold chisel naturally becomes shorter each time it is redressed or resharpened. Therefore it will eventually become too short to permit a safe hand grip; use beyond this point constitutes a wanton risk. This condition is most frequent where the employees are required to furnish their own tools.

On struck tools, similar to a cold chisel, a simple inexpensive guard can be provided. This may be a used rubber pump valve that fits snugly over the end of the chisel. In case the hammer misses the end of the chisel, the rubber guard prevents severe injury to the hand holding the chisel. Where large asphalt cutters or other hand tools are struck by a sledge, a wooden handle should be provided or the cutter should be held by a pair of tongs, permitting the person holding the tool to be out of the danger zone.

Tools are quickly rendered defective because of accidental injury to the tools themselves. Any tool can be damaged by an accident, with the result that the tool will become defective and a potential accident hazard. Wood-handled tools are especially susceptible to this type of damage. Such handles become rough and splintery, nicked, or split as the result of wear or misuse.

Attempts to repair a defective or splintered handle by wrapping tape around it should be prohibited. Concealment of the defect makes it impossible to determine if it is becoming progressively worse. Taping interferes with the balance of the tool, and, in addition, it can cause injury to the user or others because of the difference in friction of the tool handles. Tools repaired in this way will often vibrate severely, resulting in injury to the user's hands and in consequent loss of personal efficiency.

There is probably no easier way an inspector can determine the management's attitude regarding safety in the plant than by the condition of the hand tools that he observes while making his inspection. The correction of hand-tool hazards is a direct responsibility of management and supervision. When tool maintenance is not scheduled but is performed only when time and other conditions permit, it means that the tools suffer. This situation can be corrected by assigning the maintenance and inspection of tools to a competent individual and holding him directly responsible for carrying out that phase of the work. A definite system of tool-room control should be established whereby all tools are issued through the tool room and proper provision is made for maintenance and replacements. In a small plant it is definitely desirable to allocate this responsibility the same as in larger plants, although in the small plant it would be a part-time job. In any case the procedure should be definite and should insure proper maintenance of all tools at all times.

The person issuing tools should be instructed to issue the necessary personal protective equipment to the employee at the time the tools are given him. A place for tools should be provided at every bench or machine, with suitable holder or rack for the convenience of the operator.

MISCELLANEOUS TOOLS

It is not the intention of this book to mention all tools used in modern industry. However, the following miscellaneous examples should be helpful in determining specific hazards in a plant.

Knives. Knives should never be used when safer devices are available. A study of the use of knives will indicate that many of them can be eliminated. Accidents do not normally occur while knives are being used, but more frequently while they are being carried or while unprotected in storage. Very few operations require the use of a pointed knife or one sharpened at the end. A knife with blunt end or round nose presents far less hazard. For almost every job there is a knife available which has been designed for safe operation and greater efficiency. Be sure that every knife included in the tool kit is of the type specifically designed for the job. When it is necessary for workmen to carry knives, a suitable sheath should be provided. A sheath is also desirable while tools are in storage. A finger guard should be provided on each knife unless it interferes with the operation. Folding knives are extremely dangerous in use and should not be employed because of the danger of the blade collapsing.

Other Edged Tools. It is advisable to provide sheaths or cases for all sharp-edged hand tools such as chisels. These prevent personal injury on accidental contact, and also protect the tool from damage.

Files. All files should be provided with suitable handles. The use of a file without the proper handle is extremely hazardous. Files should be kept clean and in good condition.

Hammers. The hammer is normally considered a relatively safe tool; yet it is found to be the cause of many accidents. Frequently these accidents are caused by the use of the wrong kind of hammer for a job. There are many types, each suited to some specific class of work. A machinist's hammer for example is not suitable for driving nails, nor a carpenter's hammer for machinist work, nor a cobbler's hammer for stone mason work. The nature of the work should be the controlling factor in the type of hammer to be selected. Wood mallets should always be used for striking wood chisels and similar tools.

Saws. Saws can become defective through improper setting or sharpening of the teeth, springing of the blade itself, or the loosening or splintering of the handle. Defective saws greatly reduce the efficiency of the worker and may cause injuries.

Screw Drivers. Screw drivers are frequently damaged by striking them with hammers, thus splintering or cracking the handle; using them as pry bars, which bends the shank of the screw driver; or using the tool on the improper side to increase leverage. The type of screw driver selected should be suitable for the work required. The blade of the screw driver should be ground to fit the screw, and the extreme end should have parallel sides, thereby permitting the surface to contact the sides of the screw slot without the tendency to ride up that exists where the end of the screw driver is tapered. Screw drivers used on live electrical work should have insulation extending down to the tip of the blade and covering the entire handle. This insulation should be frequently inspected and tested where live work is involved.

ELECTRICAL HAND TOOLS

The maintenance problem with electrical hand tools is more important than with any other type since, in addition to the other hazards, the opportunity exists for electric shocks or burns. In this type of tool it is important that tools of good quality be purchased initially and that some provision be made for "grounding." It is particularly important for men working inside boilers, and in other damp locations, that a good ground be provided at the tool case so that the metal parts of the tool cannot become alive. This also applies to extension lights, drop cords, and other electrical equipment. In some cases it may be desirable to use completely insulated tools. This has been done if the tool case, the cord, the socket, and the guard itself are of non-conducting material. Frayed or defective cords should be replaced immediately. Every electric power tool should be equipped with an automatic power cutoff commonly known as a "dead man" control button.

The peripheral speed of portable grinders with variable speed devices should be checked to see that the maximum grinding wheel speed is kept within safe limits. The wheel itself should be secured by suitable flanges and equipped with a hood that encloses the periphery as much as the nature of the work will permit.

An operation requiring portable electric tools over a considerable period should first be analyzed to see if some other method of performing it would be more suitable. In case this is not feasible a suitable hanger or other device to support the weight of the tool is suggested. This will not only lighten the work of the operator but also increase the life of the tool itself.

The insulation resistance of all electrical tools should be tested regularly.

NEW APPLICATIONS FOR HAND TOOLS

It has been pointed out that hand tools should not be used except where actually necessary. However, at the other extreme there are many uses for hand tools which would prevent the possibility of other types of injuries. For example, the device that permits the grocer to remove packages from the top shelf of a store makes it unnecessary to use a ladder. This was the first of a great number of safety devices including: sticks to replace burnt-out electric light bulbs at unusual heights; insulating sticks to operate electric switches in disconnectors, permitting the operator to stay at a safe distance from the electrical hazard; long-handled brushes for cleaning, painting, and so forth; insulated hot-line tools for working on live electrical equipment or transmission lines; long-handled tongs for holding chisels and other devices that would be dangerous to hold in the hand; vacuum cups for removing work from punch presses; and pusher sticks for moving work or feeding work into machines where the point of operation is not completely guarded.

STORAGE OF TOOLS

Tools should be so stored as to prevent damage to the tools, make them readily available, and prevent injury to the person removing them from storage. Each of these considerations in effect prohibits storage in chests, bins, and drawers, and suggests the use of tool racks, boards, and other forms of individual support.

CONCLUSION

The provision of high-quality, well-maintained hand tools, backed by supervisory control and a training program that teaches use of all tools, will eliminate, or at least greatly minimize, the possibility of injuries to workmen. This program has many other advantages. Primarily, it is simple evidence of good management that improves efficiency of production and demonstrates management's attitude so that the rank-and-file employee can easily understand that the company is interested in his welfare.

CHAPTER VI

Personal Protective Equipment

Personal protective equipment, worn to prevent injury, is generally a secondary defense measure giving protection at the cost of some inconvenience and discomfort. Safety practices dependent upon the wearing of protective equipment are especially subject to human failure. The safety director should make every effort to eliminate the need for such equipment by causing the removal, by more positive means, of the hazards which make it necessary. Exhaust systems often eliminate the need for individual respiratory protection and dust goggles. Fixed guards and enclosure of hazardous machine parts may eliminate the need for special work suits. Processes may be altered to remove specific hazards, and other similar precautions may be taken to create safe working conditions with increased worker comfort and probably increased production. The use of personal protective equipment may seem less costly on first thought, but it involves numerous recurring expense items, such as the purchase and storing of replacement parts and equipment and the maintenance and repair of the protective equipment, all of which make it economically desirable to eliminate, if possible, the need for personal protection.

In many specific instances the complete elimination of hazards is impossible or impractical and personal protective equipment is the primary defense against injury. As an example, grinding and chipping operations cannot be made eye-safe except by the wearing of proper goggles. In other instances, personal-protection devices, such as explosion goggles in chemical laboratories and gas masks provided in refrigerating plants, are required for the safeguarding of employees in the event of failure of the plant equipment.

On all operations in which personal protective equipment must be employed, the primary responsibility for selection of proper type of equipment rests with the supervisors. The safety director in each case acts in a consulting capacity to assure that the equipment provides adequate protection with reasonable comfort. The worker must be thoroughly instructed as to the necessity for using the equipment provided and must be convinced as to the personal benefit in protecting himself from injury or ill health.

There are many brands of protective equipment on the market. Some are excellent in design and performance, while others are definitely inferior and inadequate. The safety director must select the type of equipment suitable for his purpose, probably choosing from those offered by several manufacturers. He must then choose which model or models are needed in the particular items. An effort should be made to keep the number of models to a minimum, since variety adds to the difficulty and expense of maintaining adequate replacement and repair service. However, in most cases it will be found necessary to purchase more than one style, since adequacy should not be sacrificed to simplicity.

The places and conditions where protective devices are necessary cannot be determined with mathematical accuracy. However, the decision cannot be left to the individual workman, whose inclination would be in most cases to neglect to wear them altogether. In some firms this situation is met by requiring that all persons must wear certain protective equipment at all times; in other firms certain areas or operations are designated in which or on which specific equipment must be worn. The places where, and conditions under which, protective equipment should be worn should be decided with due regard to all pertinent factors, and appropriate rules should be issued to outline the decision clearly. These rules should be enforced with disciplinary action if necessary.

Mode of Issuance of Protective Equipment. When issuing protective equipment to individuals, it is excellent practice to state that each article is to be worn only by the person receiving it. Such articles as goggles, respirators, and masks should be sterilized before being issued to another.

Most concerns furnish all protective equipment (with the exception of articles of clothing) to their employees without charge. Some, however, require the employee to purchase equipment or to furnish a deposit to cover the cost of replacement if the article is lost. Local conditions will vary, but it is generally found that the deposit arrangement particularly discourages the use of the equipment, and either deposit or purchase requirements cause employee resentment. In plants in which the employees are required to buy protective equipment, frequently the plant management handles this equipment through the store-room, selling to the employees at cost. In this way the cost to the employee is reduced, and the company is assured that the equipment purchased will furnish adequate protection.

Repair of Personal Protective Equipment. Many large firms have found it profitable and desirable to establish shops for the repair of personal protective equipment. In such shops, stocks of replacement parts are maintained, and the actual repairs are made by trained employees. This service reduces the total cost of personal protection by increasing the average life of the equipment. Such shops must be intelligently run so that unwarranted and uneconomic repairs are not undertaken.

Protection of the Eyes. The National Safety Council reports that there are now living about 8,000 persons who have lost the sight of both eyes in industrial accidents, and 80,000 who have lost the sight of one eye. The average cost of compensation alone for the loss of one eye is about $1,800. Medical expenses in such cases run to a large additional cost. The annual number of industrial eye accidents is estimated at 300,000 injuries, of which 70,000 are compensable. The annual cost of industrial eye injuries is estimated at $50,000,000.

Almost every eye injury can be prevented by the use of proper goggles. The difficulty in the situation arises from the fact that eyes are injured in so many ways that it is almost impossible to specify any circumstance under which a worker is safe without goggles. Many large companies have practically eliminated eye injuries among their employees by furnishing goggles to all their forces and requiring that these goggles be worn at all times while in the shop. Outstanding among these is the Pullman Company, which protects every employee from executive to office boy by insisting on the continuous wearing of goggles by all persons while in the shop.

It is usually the joint responsibility of the safety director and the plant supervisory group to determine which operations within the plant require goggle protection and to recommend the type of protection to be provided for each of them. Many goggle manufacturers will furnish engineers to aid in surveying the plant operations and determining the places in which goggle protection is required. Cup-type goggles are commonly used where severe impact is anticipated. Although spectacle-type goggles with side shields are also used in such circumstances, the cup type is preferred. The spectacle type without shields is used effectively on certain operations where the eye hazard is small, but these goggles lack the positive protection feature. Face shields give moderate protection against small particles or against harmful light, but they are of little value against chip impact and are not advocated for continuous use because of visual distortion. Tinted face shields are often used for protection against light rays in light welding operations, with clear-glass goggles worn beneath the shields as impact protection. The heavy welding masks, with windows tinted a proper shade for the operation, are impact resistant and are frequently worn without goggles beneath them; but, if welding operations are frequent and of short duration, impact goggles should be worn as protection against chip hazards during the intervals when the masks are raised. In such cases, the goggles are worn beneath the masks.

Prescription-Lens Goggles. Employees who normally wear eye glasses to correct their vision may object to wearing goggles over their glasses. An excellent solution of this problem is to provide the employee with goggle lenses, ground to his prescription. Tests have proved that this procedure does not materially weaken the protective strength of the lens. Ground lenses can be used only in rigid-frame goggles, where pupillary alignment is fixed.

Head Protection. Hard hats, which are now available, give considerable comfort and afford adequate protection against falling objects of ordinary sizes. They consist of impact-resistant shells supported on sweatbands or cradles by a system of lacing. The lacing must be adjusted so that the shell rides at least 1 inch above the top of the head. If a heavy object does strike and dent the shell, the impact in most cases will be absorbed without injury to the person; where the force of impact is sufficient to crush the crown, the injury suffered will be greatly reduced in severity. The hats should be made of materials that are nonconductors of electricity and are resistant to fire, water, and acid.

Another form of head protection is that afforded by the helmet (or hood). Helmets are available for protection against dust, fumes, sprays and splashes, and forms of radiant energy. Helmets, in addition to their principal protective functions, also protect the head and neck of the wearer against injury from impact. The industrial helmet is designed to rest upon the shoulders and is provided with a harness to keep it comfortably in place and away from the sides of the wearer's head.

Foot and Leg Protection. Foot guards are available to be worn over normal shoes. They provide protection against foot-crushing accidents in foundries and in metal working, quarrying, lumbering, and other tasks involving the handling of heavy objects. This protection is quite positive except in soft dirt, where the guard under pressure may sink until it is in contact with the shoe. Foot guards are heavy, noisy, and cumbersome; if used on dirt surfaces, they may become clogged with earth. Because of these disadvantages, they are rarely used except where absolutely necessary.

The standard safety shoes, with steel toe boxes, afford a more comfortable solution to the foot-accident problem. Their protection is more positive insofar as toe injuries are concerned, since they are equally effective in soft dirt or on pavement. They give quite effective protection to the arch of the foot in most cases, since most objects falling upon the shoe will be supported by the steel toe and kept out of contact with the soft part of the shoe in back of the toe box; however the protection in this regard is not nearly as positive as that afforded by the foot guard.

In most companies where moderate foot hazards exist, employees are encouraged to purchase safety shoes. In some instances a payroll deduction plan is instituted to ease the purchase. Where foot hazards exist and employees will not purchase safety shoes, foot guards are often provided by the employer.

In operations, such as foundry work, where the hazard of splashing molten metal exists, workmen wear leggings that cover the entire upper shoe surface, the ankle, and the calf. These leggings prevent entry of the drops of metal into the shoe or their spattering over the ankles or legs. The leggings are made of various fire-resistive materials.

Respiratory Protective Equipment. There are four common types of respiratory protective equipment:

1. Respirators — to remove harmful or objectionable solids or liquids from suspension in the air, by a process of mechanical filtering (screening).
2. Gas masks — to remove harmful or objectionable gases, or vapors, from the air by chemical action.
3. Airline respirators — to supply respirable air under positive pressure from an airline to the wearer.
4. Hose masks — to furnish a connection between the person

working in a dangerous atmosphere and an external source of clean air through a length of 7/8-inch tube.

The United States Bureau of Mines maintains a service of approval of respiratory devices. Approval by this body constitutes definite assurance that the device will afford the protection specified on the label of permissibility.

Respirators cannot remove gases or vapors from air because these elements pass through the filter as readily as the air itself. (The so-called canister-type respirator is an exception because, in reality, it is a small gas mask, since it contains a chemical filter.) Respirators are commonly used as protection against non-poisonous or mildly poisonous dust, metallic fumes, paint spray, and other mists. They should never be used in highly poisonous dusts, heavy metal dust, fumes, or sprays concealing poisonous gases or vapors. Respirators are designed so that the filters can be removed for cleaning or disposal and can be readily replaced and reassembled.

The canister-type respirator, previously mentioned, utilizes a chemical filter that protects against a specific gas or vapor. The respirator must be in perfect condition, properly fitted to the face, and provided with the correct canister for the gas or vapor for which protection is required. The canister must be replaced when exhausted; exhaustion may be established by the lapse of a stated period of time or by when the user begins to notice fumes or gases entering through the canister.

Gas masks employ canisters containing one or several chemical filters, each intended to protect against a single gas or a number of similar gases. The filter acts by conversion or absorption; that is, it causes a chemical reaction so that the gas is either changed to another, but harmless, gas (for example, carbon monoxide is converted to carbon dioxide) or converted to a solid which is deposited in the canister. A gas mask gives protection against only the specific gases and vapors, and only within the limits of concentration, and only for the period of use described on the canister. A gas mask should never be worn where an oxygen deficiency is known or suspected to exist.

An airline respirator consists of a face piece supported by a head harness and equipped with a breathing tube and an exhalation valve. The breathing tube is supported in such a way that it permits free movement of the head, and it is supplied with air under a slight positive pressure from an external source.

A low-pressure compressed-air line may be used as an air source, in which case an automatic pressure-reducing mechanism and a chemical filter (to remove the compressor lubricating oil fumes) must be employed in the supply circuit. Similarly, if any other contaminated air source is used, a suitable filter must be provided.

The airline respirator furnishes protection against any atmospheric condition that is not damaging to skin tissue. It is commonly used in industry in paint-spraying operations, and in atmospheres containing harmful dusts and similar elements. The sole limitation of this device is that the user is restricted to a small area limited by the airline length.

The hose mask is similar to an airline respirator except that the attached hose connections are usually supported on a safety harness worn about the waist and over the shoulders. This arrangement serves to take the hose weight from the head and to permit easy head movement; more important, the belt furnishes a convenient connection for a life line by which the wearer could be rescued if he were overcome. A length of 7/8-inch hose, through which the wearer can breathe, is connected to the mask at the harness. If the hose length is 25 feet or less, the normal breathing effort of the wearer will be sufficient to draw adequate air through the tube; for greater lengths, unassisted breathing becomes difficult and air is forced through by a pump which may be either electrically or manually operated. Hose masks afford protection against any atmospheric condition which does not attack the skin.

Warning: respiratory protective equipment protects the respiratory organs only; it cannot protect the body from damage caused by gases or other substances which directly attack the skin. For this reason, gas masks, hose masks, and airline respirators are not to be considered as protection against such substances. Effective protection against these can be achieved only by the use of proper, chemically treated coveralls, and of respiratory protection. Fortunately very few industrial gases have any such effect, and, where skin-attacking gases are formed, the hazards are well known and proper precautions are taken. Many war gases are of this nature, and, in atmospheres containing them, adequate protection is achieved only by wearing complete decontamination suits and masks.

Standard Code for Protective Equipment. The American Standard Safety Code Z2-1938, covering the protection of heads, eyes, and respiratory organs, is an excellent guide to the purchase, selection, and use of protective equipment.

Gloves and Arm Protection. Specially designed gloves have been developed for almost every type of industrial risk. Common types are the ordinary work gloves, asbestos gloves, rubber gloves for electrical insulation or for protection in chemical exposures; canvas gloves chemically impregnated to resist oil, and a large number of other types. In addition there are many special gloves designed for specific jobs, such as gloves that cover only some of the fingers, or other parts of the hand particularly subject to accident, but leave other fingers uncovered as required by the work. The safety director can, in almost every case, find a glove which will especially fit his needs; if not, the manufacturers are usually cooperative in designing and making new types.

Arm protectors have been developed to afford protection against common occupational accident hazards. Some of the types are: cuffs worn in handling metal sheets and plates to prevent wrist cuts; welders' leather sleeves which prevent arm burns from metal drops and from shirt-sleeve fires; and electrically insulating sleeves worn in high-voltage, live-maintenance work. In each of these jobs, proper gloves are required for the protection of the worker; the cuffs or sleeves furnish added security.

Body Protection. Many items of clothing are available for the protection of various parts of the body against specific exposures. Some of the more commonly known are leather clothing for welders, asbestos suits used in rescue from airplane crash fires and other similar fire conditions, lead aprons in X-ray work, and chest protectors and similar items designed to eliminate impact risks. Pads are built for persons carrying heavy materials upon their shoulders. Many other items are provided for particular industrial hazards.

Conclusions. Where an industrial hazard is found to exist, the first effort should be to eliminate the hazard. Where this is impossible or impractical, personal protective equipment should be used. The personal protection required for each job should be specified and its wearing enforced by the supervisors.

All items that intimately contact the skin should be restricted to a single wearer or should be sterilized before transfer between persons. All personal protective equipment should be adequately maintained to assure good condition. To simplify this work, each plant should standardize as few different types of equipment as will afford satisfactory protection. (For detailed information on the sterilization and maintenance of protective equipment, the reader is referred to *Special Bulletin No. 3* of the United States Department of Labor.)

Where unfamiliar problems requiring personal protective equipment arise, salesmen and other representatives of the equipment manufacturers are usually found to be extremely cooperative in suggesting standard types of equipment suitable for the work, or in developing new designs for the application.

CHAPTER VII

Employee Training

History of the Development of Training Programs. During the past twenty years continuous and progressive changes have been made in the field of employee training. In the early years, safety was taught as a separate entity, not associated with normal work. This system had several deficiencies. It had only two possible paths to follow: either it could prescribe safe ways to do work, hoping that the employees would follow these ways instead of the processes desired by their supervisors, or it could attempt to teach employees the broad aspects of safety, leaving to the individual the application of these principles to his daily work. Neither course could be greatly effective. The first caused conflict between safety and production which did not benefit safety, and the second put the safety director's responsibility completely upon the worker, who was incapable of assuming it.

In 1928 the American Engineering Council established the fact that safety was an integral part of good production, proving that, where production schedules were met, the accident-prevention activity had been well developed and that, where production was efficient, accident prevention was automatic. The recognition of the basically sound policy, that the only way to do a job is the safe way, had an immediate effect upon safety training. Efforts were made to bring together the safety personnel and the production supervisors to devise and institute ways of performing work safely. The foremen's conference plan followed; it was conceived with the thought of making each foreman aware of his ability to utilize his knowledge for the development of safe practices, and the subsequent transmission of his learning to his subordinates. This proved an excellent method, providing a means of retraining the older employees without a complete stoppage of normal activities. The foremen's conference idea worked very well as long as employee turnover remained slight, and it is still the best technique where jobs are varied and workers are reasonably well experienced.

Where operations are of a repetitive nature, the detailed analysis of each operation was found desirable for the purpose of developing efficient, safe methods. This is generally known as job analysis. In analyzing a job, every required movement of the operator is studied; the tools and devices required for the work are ascertained; and the movement of material to and from each machine is reviewed. On the basis of this study, the job analyst rearranges the steps in a procedure to minimize machine adjustments and operator movements, provides convenient resting places for the tools when not in use, and arranges for convenient delivery of material and removal of completed work pieces. The analysis of jobs is of course a highly specialized field and not a function of the safety department. On the basis of job analysis, the physical characteristics required of an operator can be accurately determined and safe placement of employees with regard to their physical impairments is possible.

Safety directors in organizations employing job analysts study the analyses which have been made and watch the actual operations so that they can seek modification of the job layout and cause the installation of necessary guards to eliminate hazards incident to the work. Safety engineering carried on in conjunction with job analysis has proven extremely effective, and, in fact, this combination offers the best prospect for the development of a perfect accident-prevention technique.

With the increase in production caused by war needs, industry has been forced to employ vast numbers of people without previous training. At the same time war-time conditions have brought about plant specialization, with an entire plant manufacturing a few simple parts rather than complete mechanisms. These factors in their joint effect have produced a great number of single-operation mechanics, each trained to do only one task and continuously employed in that operation. For these people, the most effective training is that based on job analysis, with little or nothing left to individual initiative or decision. Obviously, because of the number of new workers, the task of training them in their jobs has become too time-consuming for the foreman to handle; consequently this work has been shifted to government- and company-operated schools. This combination has already proven itself a practical answer to war-time conditions, but it probably would be impractical for application in the post-war period when it may be assumed that shops will return to more varied work, requiring workmen of greater individual skill and responsibility. Therefore it would be unwise to discard the foremen's conference idea and other peace-time measures as outmoded; rather, they should be held in reserve for application when the need for them again arises, as it will.

Need for Training. A systematic training program provides speedy induction training of new employees and frees the production forces from the delays which are unavoidable if training is done in the plant. It also provides a means of preparing present employees for new jobs as the plant work changes or a means of upgrading, that is, preparing employees for promotion.

The policy of promoting deserving employees to better and more highly paid work is common to all plants. Such employees, by being specifically trained for their new duties, are made competent to assume the responsibility of their assignments as soon as the promotions become effective. This avoids the stumbling process of requiring each promoted employee to find his own way in his new job.

Accident-Prevention Interest in the Training Program. High accident rates are commonly experienced among new employees, newly transferred employees, and employees working on new operations, new equipment, or new processes. It is therefore particularly important from the accident-prevention viewpoint that these groups be given special training before they are injured by the unfamiliar surroundings or acquire faulty or defective working habits. The entire training program should be designed so that these employees are off to the right start.

Types of Training Programs. There are many kinds of training programs from which a program that will most adequately fulfill the needs of the organization may be selected. The most commonly employed types are described in the following paragraphs.

On-the-Job Training by Foremen. The system of training of new employees by the foremen is the oldest type of shop training. The foreman instructs the employee in the mode of operation of the machine and in the method to be followed in accomplishing a specific job detail; he then permits the employee to perform that job under his direct supervision until the employee is reasonably familiar with it; then the employee is allowed to perform the job a number of times under general supervision, until he develops a degree of skill and competence. This process is repeated with each job the employee will be required to perform. Many foremen employ a form of training checklist to record the progress of training.

The chief difficulty of foreman instruction is that the foreman must continuously supervise and direct the activities of all the other members of his group and often cannot afford the time necessary for adequate instruction. Foreman instruction can be successful only where the number of new employees is very small.

On-the-Job Training by Experienced Operators. This method of inductee training is a development from the foreman-instruction system. Here, the training function is delegated to experienced operators, who assume the successive responsibilities for instruction, observation, and supervision. The advantage of experienced-operator instruction lies in relieving the foreman of the distraction from his normal duties. It has several marked disadvantages: the productivity of the experienced operators suffers because of the added work of supervision; many good workmen resent or fear the supervisory responsibility; and many are incapable of imparting their knowledge to others, or reluctant to do so. The entire success of an experienced-operator training system is dependent upon the careful selection of the proper instructor-operators.

A variant of the instructor-operator system which has frequently been used with considerable success is the doubling-up technique employed during rapid plant expansion. One new employee is assigned for instruction to each experienced operator in a department. The new employee observes the operator, learns the location and purpose of each control, and, finally, operates the machine under the continuous, direct supervision of the operator. In this way, the new employee is enabled to operate a duplicate machine in the expanded part of the plant. This system is applicable only to work requiring little individual skill, as the operation of automatic machines in assembly-line production.

On-the-Job Training by Special Instructors. In this system, certain employees are removed from normal production work and assigned to the task of instructing new employees. This differs from the experienced-operator type of training only in the fact that the instructor is not expected to maintain productive work.

A fault commonly found with the special-instructor type of training is that the instructor becomes bored and is automatic in his instructing. He then fails to appreciate the student's position and point of view and may lose patience and interest when the student does not grasp a subject promptly.

Vestibule Schools. Vestibule schools are usually located on the premises, equipped with duplicates of the types of machines used in the plant, and designed to meet the needs of the particular company. The chief advantage of this plan is that it gives management an opportunity to check the reaction of the beginner under approximate shop or office conditions. It also serves as the reservoir of employee material. In slack times employees can be released for retraining. When an emergency develops, the training program may be suspended entirely for a short period.

The disadvantages of this plan are its cost and the difficulty in obtaining suitable instructors.

Company Schools. The complete school systems maintained by some companies are an important factor in the maintenance of employee interest and morale. These schools also are equipped with duplicates of the plant equipment. Aptitude tests are given in order to determine the type of training for which each person is qualified. These schools are very efficient and are highly recommended. A typical example is the Ford Training School, which was opened in 1935 with twenty-five students and six instructors; within two years it grew to two hundred and fifteen students and thirty instructors. Another is the school maintained by the Pittsburgh Division of the Westinghouse Company, which offers, in addition to shop training, special courses in languages, public speaking, and similar subjects.

Apprenticeship System. Modern production requirements do not permit the time necessary to follow the old method of apprenticeship training, which required an apprentice to serve three to eight years under a skilled craftsman, during which time he received very little, if any, compensation. The modern apprentice system is best described as a cooperative endeavor between an industry and the trade or vocational schools in the immediate vicinity. Schedules are worked out whereby the trainees spend part of their time at the school, the remainder at work in the plant. The apprentice is assured of a minimum wage during the training period and of ultimate employment, at work for which he has been trained, when the training period has been successfully completed.

Foremen Conference Training. Foremen conferences, if properly conducted, are the most effective means of training experienced personnel in accident prevention. This method is especially valuable where a number of foremen are doing similar or comparable types of work. In the conferences, the stress is not specifically upon safety as such but upon the most efficient methods of performing work, with safety a natural result.

The conference plan is not necessarily a part of the regular training department. It is usually established as an intradepartmental activity. However, the preliminary conferences and advisory group meetings are often sponsored by the training department. Conference meetings are usually held on company time by groups of about twenty foremen, in rooms provided with blackboard and other equipment where the foremen have privacy and can frankly discuss their mutual problems. An especially qualified leader should control the discussion. This type of program is particularly effective for retraining experienced foremen and for developing new foremen. Foremen's conferences have also proven effective in developing or revising rule books and in devising work procedures to meet new conditions or requirements.

Selection and Initiation of a Training Plan. No attempt should be made to select the types of plans to be followed until a complete survey has been made of the training problem and until all of the important jobs frequently performed within the plant have been analyzed. In planning and operating any training program, cost should be constantly kept in mind. There are many ways to keep expense down without materially reducing the efficiency of the training program.

The person responsible for the training program should operate on a staff basis, obtaining the full and complete cooperation of all other executives and department heads. The initial training groups should be kept small and should be selected with great care. The outline material should be well balanced and not devoted entirely to work procedure and methods but should place proper emphasis on human behavior and the modern concept of proper treatment of employees. The subject material should be revised after completion of the training of the first groups to correct any faults found in this initial step. Full use should be made of visual aids: charts, graphs, sound slides, motion pictures, cuts, and models. The use of obsolete books or inadequate or improper outline material should be avoided. The instructional material should be constantly revised and kept up to date. Improvements and changes should be incorporated in the instruction manuals at or before the time they are made in the plant itself.

Preliminary Steps in the Setting up of a Training Program. Before any training program is undertaken, there are certain preliminary steps that are desirable. First, information regarding current training programs in other companies should be obtained. Some of the companies most successfully operating training plans are the General Motors Corporation, American Rolling Mills Company, Western Electric Company, B. F. Goodrich Company, and Socony Vacuum Oil Company. Many of these companies will furnish, upon request, printed outlines of their courses and other related information. The United States Office of Education, the American Management Association, the War Production Board, and the Labor Department Division for Training within Industry are all anxious and willing to be of assistance in the promotion of this work.

The most favorable accident-prevention experiences are obtained by the cooperation of the supervisory staff and not by threat or fear. This is accomplished by placing the full responsibility for efficient production and accident prevention upon the supervisors in direct charge of the work, with the safety director having no "line" responsibility for accident prevention. The training program should be so designed as to make this point clear.

Companies planning to establish a training program should make a survey of existing training needs about which information can be conveniently obtained. Supervisory training is probably desirable as an initial step, since it is the keystone of any plan for industrial education. The next group to receive attention should be the job instructors responsible for breaking in new employees. It is here that the job-instructor training program of the War Production Board should be utilized. The remaining groups, in order, would be the rank-and-file employees and the new and transferred employees.

The primary consideration in offering any course should be that it must be of direct value to the employee in his work.

Fundamental Training Policies. The training program should be placed in the hands of competent instructors. Knowledge of the work alone is not sufficient qualification for instructorship;

the person must be capable of transmitting this knowledge to others. Nor is teaching ability alone sufficient qualification. If plant foremen are used as instructors, they should be trained in good teaching technique and methods. If experienced instructors are employed for this work, they should be familiarized with the equipment in the plant and the job procedures followed. In any case, the instructor can be judged by considering the employees who have completed training under his supervision; if they are unsatisfactory, the instructor is not competent and should be replaced.

Persons selected for the training course should be examined critically as to aptitude and physical fitness. This applies both to new employees and employees being prepared for advancement. With specific reference to new employees, the school training program should be supplemented by a period of on-the-job training to aid their orientation to shop conditions. On-the-job training should, wherever possible, be limited to foremen who have demonstrated training ability.

If an apprenticeship program is followed, instead of training school instruction, each apprentice should be moved from job to job according to an established schedule. Provision should be made to accelerate the training of individuals who absorb knowledge quickly. Those who fall behind the established schedule should be considered for rejection.

Selection of New Employees by Tests. Industry has devised numerous tests to aid in the selection of new employees for training. Some of the tests most commonly used are as follows.

1. Aptitude tests, that are designed to check the personal suitability of the applicant to the work, are valuable in selecting employees for manual tasks, especially for tasks requiring unusual dexterity or other special physical qualifications.
2. Check tests, in which the applicant is required to check which of several proposed statements is the correct answer to a given problem, furnish a permanent record of the applicant's ability and can be specially designed to fit any type of work.
3. Written tests, in which the applicant is required to supply answers to specific questions, can be applied to potential office workers but are of little value in manual employment.
4. Visual tests, in which the applicant is required to identify specific tools or machines shown in photographs, can be designed to check the general mechanical background of a new worker or

to check the qualifications of an experienced mechanic applying for employment.

5. Work tests, in which the applicant is required to perform a regular trade task, can be used only with experienced persons applying for employment as qualified mechanics.

Selection of Employees for Promotion. Management often appoints foremen primarily because of their job knowledge, seniority, or some other similar factor. There are many other necessary qualifications that should also receive thorough checking before the appointment is made. Foremen must possess the quality of leadership and should be of good character. When persons are improperly selected for promotion or responsibility, management is usually reluctant to admit the error and hesitates to take corrective action. Such mistakes are often the fundamental cause of industrial accidents.

Selection of Training Material. Before discussing course outlines, it might be well to reconsider our training objectives. These may be: first, to acquaint new employees with their duties; second, to increase the skill of workers already on the job; third, to prepare employees for advancement; fourth, to maintain employees' interest and morale. After we have considered these objectives, we may then turn to the problem of what the training program should include.

Obviously it is not possible to adopt a custom-made program to the particular needs of a plant. The program must be developed. It must be based on extensive research into the most efficient methods of performing the work involved. In teaching manual skills, time and motion analyses have proved most valuable, since a high degree of speed and proficiency is necessary. Much valuable information for use in training programs may be obtained from the supervisory and executive staff. This means that close cooperation of the training director with this group must be maintained.

Provision must also be made for possible changes in plant operation techniques that make it difficult for the training staff to keep in intimate touch with actual job procedures. The training director should be kept informed of all proposed changes in work procedures or methods.

Common Mistakes. One of the most serious mistakes that may be made in establishing a training plan is to place it too far down in the organization. In order to be effective and to function efficiently, the training organization should be placed high in the company organization. Failure to do this results in the entire training activity being considered as a step-child and not carrying the necessary prestige.

Another common fault is to depend almost entirely upon the lecture plan. This is particularly true where the safety director is called upon to participate in safety training classes. While there are some advantages to the lecture plan, the conference method is so far superior that lectures should be kept to a minimum, if used at all.

Classroom Facilities. The average employee gauges management's opinion of any activity, to a large extent, by the visible indication of management's interest. Therefore, classrooms should be well constructed, well equipped, and maintained in good condition. Every consideration should be given to the students' comfort and convenience. Blackboards, working models, visual aids, charts, graphs, and all other required devices should be furnished.

Instructor. The selection of the instructor is particularly important. In addition to his knowledge of the subject, he must have the ability to impart his knowledge to others, and to understand people. Full-time instructors may be employed, or supervisory employees may assume the function on a part-time basis. Older men are generally more satisfactory because men of middle age, or over, resent instruction from a younger man. The fundamental success of a training program depends upon the ability of the instructors. Personnel aptitude in the instructor is equally as important as job skill. Persons selected as instructors should be thoroughly trained and should be released from all job responsibility during the period of their training.

Cost of Training Program. Inadequate supervision of a training program may permit costs to become excessive. Costs can be minimized by careful attention to the planning of the entire program. Where classes are given on company time, considerable expense that is not easily detected may be involved. Salaries paid to instructors are comparatively small parts of the entire training costs and should not be altered in the interests of economy, since competent instructors are essential to the success of the program.

Indirect Training. Where an elaborate training program is not justified or where a major part of the training work has been completed, it may be desirable to curtail these activities; yet means must be provided to maintain interest and to keep the quality of supervision and worker efficiency at a high level. This may be done in numerous ways. Competition between departments, based upon accident experience, rate of production, or some other comparable factor, can be utilized; comparative data should be released periodically, perhaps on a monthly basis. Other commonly used means of sustaining interest are memberships in such organizations as foremen's clubs, the provision of literature to a select group of employees, and the preparation and distribution to employees of instructional material designed to supplement the training program. These are inexpensive methods of securing indirect training.

The following is an example of management information provided by the Elliott Service Company, 219 East 44th Street, New York City, and is reproduced by their permission.

HOW TO PULL TOGETHER

There are certain specific ways in which you can and should cooperate with other departmental supervisors. Here is a list of things that you can do:

1. Be careful in the promises you make to other supervisors, and then be sure to keep your promises.
2. Don't make other supervisors wait unnecessarily.
3. Make suggestions to other supervisors in a helpful manner.
4. Be ready to lend the other supervisor men, material, or equipment.
5. If you have a complaint about another supervisor, talk to him about it first — don't make the complaint to his boss.
6. Don't be afraid to work overtime for the other fellow; his turn to help you will come next.
7. Give the other supervisor any information you have which will help him.
8. Ask for advice and suggestions from the other supervisor and show appreciation for the help he gives you.
9. Be ready to offer the other supervisor a lift rather than "take him for a ride."
10. Be careful not to "wish a lemon" on the other supervisor when he wants you to transfer or lend him a man.
11. Regard the other supervisor's difficulties sympathetically and help him out of them whenever and however you can.

If you will follow these suggestions carefully and conscientiously, you will find that other supervisors will go out of their way to cooperate with you. By cooperating you will help yourself as much as you help others.

Conclusions. The adoption of an efficient training program is a great aid to the entire accident-prevention program, but this is only one of the many outstanding advantages of training. Its principal effect is the careful selection, placement, and training of all new employees, an effect that is beneficial to production as well as accident prevention.

The adoption of an effective training program for new employees will soon indicate the need for retraining supervisors and foremen. The latter groups note the difference in the trained new employees' methods, as compared with their own, and in many cases request retraining.

The training program can and should be very definitely " tied in " with the upgrading and advancement program. A good training program provides an excellent guide for use in the selection of employees for advancement to supervisory positions. A large percentage of industrial accidents and injuries may be traced to mistakes made by management in allocating responsibility and authority to individuals who were incapable of accepting that trust.

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CHAPTER VIII

Maintaining Interest

The maintenance of interest in accident prevention includes all the devices and methods used to keep the safety problem constantly before all employees. The safety director is usually responsible for devising the methods, setting up the procedures, and initiating the steps necessary to carry out this part of the program. There are three specific objectives toward which the material must be directed. First, the chief executive himself must receive certain information regularly to sustain his interest. Second, the supervisory group, department heads, and foremen must be reached. Third, the interest of rank-and-file employees must be maintained.

Chief Executive. The safety director must supply, for the chief executive, information pertaining to the current accident experience and all new safety developments within the plant. At stated times (perhaps monthly) he should submit regular reports to the chief executive, indicating the accident-frequency rates of the various departments. Tabulations showing comparisons with the same period in other years, indicating the change or trend, could also be included in such a report. It may be desirable to submit a brief memorandum suggesting plans of action which could be undertaken. This provides the executive with the basic material to give credit to the departments improving their records and also to bring poor records, with suggestions for improvements, to the attention of the department heads.

The executive is deeply interested in the comparison of the accident experience of his company with that of the industry and should be furnished with comparative frequency and severity rates. In addition, detailed reports of all fatalities and other major injuries should be submitted promptly to the chief executive.

Supervisory Force. The supervisor is particularly concerned with the record of the group reporting to him and is also extremely interested in the showing made by the department with which he is associated. He is therefore interested in the comparison of frequency and severity between departments, and between the major groups in his own department. He should have these comparisons presented to him on a monthly basis, together with the important details of all lost-time accidents in the company. He should take an active part in investigating, coding, and reporting all accidents within his jurisdiction.

Where the department head is a member of the executive or central safety committee, it is desirable for him to discuss, at the committee meetings, accidents occurring in his department. Additional information may be furnished by the safety director. Intradepartmental safety committees are normally used in groups where the accident rates justify their existence.

Some form of training program is essential in any organization to maintain interest in safety. This is particularly true for foremen and supervisors. The best type of training for this purpose is the conference method. These employees should be encouraged to participate in other training programs conducted in the community, such as courses in engineering, science, and management war training, and courses designed specifically for improvement of supervision and foremanship.

It may be desirable to send some of the supervisory employees to meetings of the local safety council and local safety conventions, and on occasion to send a representative to the annual meeting of the National Safety Council. There are two types of supervisors to be selected for attendance at such meetings. First, in recognition of service, are the persons who have done an unusually good job in accident prevention. Second, there are the supervisors who have never been quite sold on the idea of safety.

If company executives are qualified to do so, they should be encouraged to accept invitations to speak at local safety meetings and at annual meetings of the National Safety Council. This increases their interest in and acquaintance with accident-prevention matters, and has a convincing effect upon other executives attending.

Figures on the cost of accidents are essential for department heads and other supervisors in order that they may understand the expense involved. The safety director can make good use here of the four-to-one ratio existing between direct and indirect costs. (See Chapter XIX, " Accident Reports and Records.")

Rank-and-File Employees. This group is the most difficult of the three in which to arouse and maintain interest. Any material used must be very clear and relatively simple. Cost figures and statistics have a poor effect upon them, but thermometers, bulletin boards, signs, suggestion systems, safety instruction cards, workmen's committees, safety contests and campaigns, articles in the company news publication, motion pictures, and sound slide films are quite effective. All of these devices are useful in keeping workers interested in safety and will be discussed individually.

Thermometers. Large-size accident thermometers or clocks, showing the number of lost-time injuries in the plant during a given period, may be mounted near the plant gate or at other locations where a number of employees congregate.

Bulletin Boards. Bulletin boards, to be effective, must be very carefully located, well illuminated, properly maintained, arranged in a neat and orderly fashion, and changed at least every two weeks. It is advisable to have bulletin boards enclosed in glass with locked doors, and to have the supervision of display material placed with one authority. Attractive posters may be obtained from the National Safety Council. Local posters may be obtained from the local safety council. An effective device is the poster contest among employees, utilizing the selected posters for bulletin board display.

If the company employs an advertising department, its cooperation should be secured in designing posters concerning specific plant safety problems, in preparing information for transmittal to employees, and in other avenues in which its knowledge of the means of persuading and convincing persons would be useful.

In order to direct and focus attention on the bulletin board, it may be desirable to subscribe to some news syndicate furnishing interesting photographs which may be mounted in the center of the board. This will serve as an attraction to induce workers to read the other material displayed on the bulletin board. Each piece of bulletin board material should bear the date of posting and the date to be removed.

Signs. Large signs, using pertinent slogans, may be displayed on outdoor water tanks and inside buildings on large bridge cranes. These should be changed before they grow stale.

Warning signs placed at points of potential accidents are useful and effective reminders. Signs, placed at strategic points, that relate what is to be done in case of injury, or similar general information, are helpful in making employees aware of company policy on these matters.

Suggestion System. The suggestion system is not necessary in a plant that has well-trained supervisory employees and foremen who will pass along to the executives the suggestions they receive from employees. But in almost every organization there are many situations that retard or perhaps completely halt the flow of ideas from the bottom to the top of the organization. A suggestion system provides an outlet whereby ideas may reach a point high enough in the organization to receive executive consideration.

There are many plants which feel they establish a suggestion system by the simple process of installing a few boxes and marking them "Deposit your suggestions here." This will in no way encourage employees to take such action. To be effective, a suggestion system must be carefully planned, well regulated, and maintained. Every suggestion received should be acknowledged by letter. Suitable awards made regularly and given sufficient publicity stimulate the interest of employees. An effective plan is to allow the suggester to remain unnamed until the suggestion is acted upon; if considered advisable, his identity can be concealed indefinitely.

When a suggestion system has been working effectively for a calendar year, it may be well to review the outstanding safety suggestions that have been accepted and make a special award for the one deemed most valuable.

Safety Instruction Cards. The National Safety Council has instituted a series of safety instruction cards that now number several hundred. These cards give detailed and specific information of considerable value in the promotion of the accident-prevention program. There are numerous ways in which these cards may be used among groups of employees. Complete sets should first be made available to all supervisory employees and foremen so that they may be permitted to select the cards which they feel are most suitable for their groups; those can then be purchased and distributed individually to the employees. Each card bears an identifying number, so that the required cards may be requisitioned in any desired quantity according to serial numbers. They are relatively inexpensive and are an excellent method for maintaining employee interest.

Workmen's Committees. Assigning a number of employees to serve on the workmen's committee is an excellent plan for maintaining interest. Such membership should be rotated frequently to reach the maximum number of employees. This works upon the theory that one's interest in any program depends to a large extent upon whether one is given something to do. The effectiveness of this plan depends upon how well it is organized and how the meetings of the workmen are conducted. A plan which has proved quite effective in many industries places the workmen's committee directly under the supervision of a safety inspector. The latter attends meetings, usually acting as chairman, and accompanies the committee on its inspections and accident investigations.

Contests. There are many advantages and disadvantages in various types of intracompany accident contests. The outstanding example of group rivalry among plant employees is the use of the white elephant. This plan provides that a small-sized white elephant be placed upon the desk of the foreman whose group has had the worst accident experience during the past month. It remains there until this dubious honor is won by another department. (Considerable detail concerning safety contests may be found in *Safe Practices Pamphlet 74* prepared by the National Safety Council.)

Safety contests tend to grow stale rapidly and therefore should be varied frequently to avoid loss of effectiveness. If it is found that interest in the results of the contests lags or disappears, it is best to discontinue them for a period, and in some cases altogether.

Publicity. Those in the plant responsible for the promotion of the accident-prevention program should take advantage of every opportunity to obtain photographs of interesting safety devices, improved work procedures, and other practices which may be of interest to other employees. Local pictures showing the plant personnel are an incentive to interest and should be used either on posters or in the company house organ. These may be accompanied by appropriate articles using the names of all employees involved.

Motion Pictures. There are many sound motion pictures now available which are of considerable value in industrial accident prevention and may be shown during the noon hour or at some other convenient time, with attendance optional. The traffic and home safety groups have prepared a large selection of suitable safety films.

Sound Slide Films. There are a great many valuable sound slide films now available. Many of these have been prepared by the National Safety Council. Many of the larger plants now have projector equipment; where machines are not available, they may be rented at a moderate charge or borrowed from some of the local insurance companies.

It is desirable to use sound slide films in the plant to fill part of a committee's meeting time or part of a lecture program. Sound slides run fifteen to twenty minutes and may be selected from subjects that are pertinent to the problem being discussed. These films contain highly concentrated and condensed material and furnish a convincing presentation. (See Appendix II.)

Conclusion. It should be understood that no safety program can function without the wholehearted support and cooperation of every employee. The top management, the supervisors and foremen, and the rank-and-file employees all must work hard to prevent accidents. They must all realize that accidents are caused, that they don't just happen, and that they can be prevented.

Safety must be made a part of every employee's duties; it must not be permitted to become a function of a single person, a group, or a class. The primary responsibility of the safety director, or the person in charge of the supervisory safety functions, is to act as technical adviser in the accomplishment of this objective.

3

IMPROVEMENT OF PLANT

CHAPTER IX

Accident Causes and Sources

An accident is not an isolated occurrence; it is one of a series of related events. Preceding the accident, there are several actions or omissions that are the accident causes. The accident results from these causes and from some contributing physical conditions that are the accident sources.

Modern accident prevention recognizes four types of accidents, divided as to preventability of their causes and sources. These are accidents that are: (*a*) impossible to prevent, (*b*) beyond the control of plant personnel and management to prevent, (*c*) impractical to prevent, (*d*) capable of practical prevention.

The first group consists principally of accidents resulting from natural causes. The second is made up of those third-party accidents which are solely the result of the action of the third party. These two groups comprise a very small part of the entire number of accidents (probably less than 5 per cent) and they cause about the same percentage of the total accident loss.

The third group is composed of accidents of two types, those in which the elimination of the hazard would cause the creation of a greater hazard, and those in which the cost of prevention outweighs the potential injury so that prevention is not economically sound. This group is large in number, but, since most of the injuries included in it are slight, it causes only a minor part of the accident toll. Failure to recognize the existence of this type of accident inevitably leads to unjust cause assignments and employee resentment of the accident-prevention program.

The fourth group contains about half the total number of accidents and causes far more than half of the accident toll. It is among these accidents that effective prevention is possible.

In most accidents the direct causes are human failings, most frequently those of the victims of the accidents. This has caused many plant executives to adopt a self-defensive attitude which expresses itself by placing blame for the accident on the injured person. The fallacy in this reasoning lies in the fact that the work will continue to be done by human beings who will be subject to the same human errors. Blaming them for their injuries does not in the least reduce the cost of an accident; neither does it relieve the owner of responsibility; nor does it prevent a repetition of the accident. At most, it relieves the temper of the executive, probably at the cost of lowered plant morale resulting from the apparent martyrdom of the injured party.

Modern safety engineering recognizes the human factor in accident prevention and tries to work out a means of prevention which will be practical within the limits of human nature. Thus, it realizes that few accidents are caused by willful desire on the part of the injured persons to hurt themselves and recognizes the ineffectiveness of punishment for accidents. It recognizes that many wrong decisions which become accident causes result from the inadequacy of instruction of employees. It recognizes that many thoughtless or careless actions are actually bad work habits, and it attempts to eliminate them by substituting good work habits. It recognizes that fatigue is at the root of most late-morning and late-afternoon accidents, and it institutes mid-morning and mid-afternoon breaks to relieve monotony and prevent fatigue. It recognizes that a person can concentrate his vision on only one small area and furnishes protection against all hazards which are within his reach but beyond his field of vision and concentration.

The foundations of accident prevention are placement of persons in jobs for which they are properly qualified, employee training in the proper way of performing the work, and engineering revision of physical conditions which otherwise might become the source of accidents.

Employee training starts before the employee is hired or even interviewed. It starts through the job analyst of the large plant or through the foreman of the small plant. The job to be done is planned, step by step, in the finest detail. Each step is studied individually to insure that it is not inherently hazardous and that it is not wasteful of time or effort. After the job is thus planned, the safety director reviews it, checking specifically for any accident risks which may have been overlooked. By the time the plan is approved, it is probably the best and most efficient method of doing the required job with the available equipment.

When the new employee is hired, he is taught not only the use and operation of his machine, but also the exact method of doing the job. He is not taught operations at one time and safety at another. The two purposes (efficient operation and safe operation) are both served by the single instruction in the best overall method. As a matter of fact, the new man is not made conscious that he is being taught safe operation because all his instructions come from one source and form one continuous story.

Accident causes and sources are important to the safety director because, in most cases, the prevention or control of accidents requires the control or elimination of accident causes and sources. In general practice, a source, a cause, and, possibly, a responsibility are assigned to each accident. This is not done with any idea of pointing blame at the injured party or at any other employee. Its only purpose is to aid in intelligent control or elimination of either cause or source.

If accidents are statistically arranged by causes, a great aid is rendered the safety director in pointing out which of the causes occur most frequently. Thus, if in a specific plant a considerable number of accidents are traced to lack of instruction or inadequacy of instruction of employees, the safety director knows that an instruction program should be instituted, or that, if one exists, it should be strengthened. If a large number of accidents are traced to fatigue, the safety director pioneers for the adoption of some of the approved methods of fatigue control, as for instance, mid-morning and mid-afternoon breaks or rest periods, music, or other devices. If unsafe practices of employees are the cause of a large number of injuries, an apparent need exists for the institution of job analysis and the design of proper working technique.

The circumstances or conditions which are frequently found to surround accidents are the sources of accidental injury. Statistical treatment of accident sources has an effect identically similar to that of the treatment of accident causes; that is, it points out those accident sources which most frequently cause injury within the plant. This high lighting of weak spots greatly aids the detection of inherent hazards and, of course, suggests the proper corrective action. The following is a list of the most common injury sources:

Injury Source	*Corrective Action*
Handling objects	Improved methods of handling; conveyor belts or roller system; stackers; industrial trucks; rerouting of materials through plant.
Mechanical apparatus	Guarding of equipment.
Falls	Provision of guard rails and chains around platforms or other elevated places; detailed study of ladders, their purchase, maintenance and use within the plant; correction of such poor floor conditions as slippery, uneven or worn floors.
Using hand tools	Inspection of hand tools at frequent intervals; the adoption of mechanical devices to replace hand tools; the use of proper guards on hand tools; check of the conditions of storage of tools.
Stepping on or striking against	Correction of housekeeping conditions; check aisle width and protrusion of work pieces or machine parts into aisles; check for low bridge hazards, and pad or paint such low bridge hazards as may be found; check illumination throughout the plant.
Falling objects	Condition of storage of equipment and work pieces; improper use of ladders; lack of toe boards around platforms and ledges; avoidance of double decking, that is, having one employee work beneath another.
Electricity, explosives, heat	Electricity — check grounding of permanent electrical equipment; check the insulation testing of portable equipment; check electrical circuits and switch boxes for exposed live parts; check the type and kind of portable equipment used throughout the plant for its safe design. Explosives — check need for having explosives on the plant premises, and, if they cannot be eliminated, check the conditions of storage and use of such explosives; if possible, isolate these materials to reduce the risk to as small a number of employees as is possible. Heat — check ventilation of plant buildings; investigate need

Injury Source	*Corrective Action*
	for salt tablets; in outdoor work, check propriety of employees' clothing for the weather conditions; instruct employees exposed to heat in needs of proper diet and proper personal hygiene and care to prevent injury; check exposed hot surfaces; check apparel of welders, firemen, and others occupationally exposed to burns.
Harmful substance	Check need for presence of such substances in plant; if they cannot be eliminated, check plant practices in handling and using such substances and assure that these practices follow the accepted good practices for such work.
Struck by	Note: see falling objects above; also the following — if eye injuries from foreign objects are classified in this group, check locale of such injuries to see if an undue concentration occurs in any one place; if such is the case, check the sources of dust or other foreign objects to ascertain if they can be eliminated; check protrusion of moving parts of machines into aisles.
Vehicles	Check use of aisles for vehicular and foot traffic; check piling of materials on vehicles with special reference to the scope of vision allowed operators of such vehicles; check width of aisles used for industrial vehicles. Check the location of such facilities as timekeeper's office, lunch room, toilets, locker rooms, etc., with reference to their proximity to main traffic arteries. Remove all such sources of injury as may be within the control of plant management. Instruct employees in the proper precautions and enforce good practices with regard to pedestrian and vehicular traffic control.

In addition to the above, the injury-source table generally includes a miscellaneous item that is of course necessary for statistical purposes. In the analysis of the accident experience of any plant, this classification should be small, in fact so small as to be inconsequential. If it is found that a large number of accidents are in the miscellaneous classifications, a need is indicated for a further subdivision of the accident source code. In other words, in that particular plant a new code designation, or perhaps several new code designations, should be recognized and tabulated. If a great number of the accident sources are defined as indefinite or unknown, an obvious need exists to investigate accidents more thoroughly and to obtain more definite and positive information.

Similarly, in the statistical treatment of accident causes, the analysis, by cause, of any plant-accident experience will indicate the lines along which accident-prevention effort can most profitably be expended. The following is a list of the commonly accepted causes of accidents and the corrective action which each accident cause suggests.

Accident Cause	*Corrective Action*
Improper or inadequate instruction	Job analysis and study followed by proper instruction of employees in the approved method of performing work.
Beyond physical or mental ability of employee	Study of the placement of employees in hazardous occupations.
Physical or mental condition of employee; fatigue, weakness, temper, emotional instability	Pre-employment examination of employee; periodical physical check-up and re-examination; study of job-placement procedure; elimination of fatigue through rest periods, varied occupations, or similar devices.
Unsafe practices	Study of the methods commonly used in the plant for doing the particular job; check availability of proper tools, equipment, and protective devices; check supervision of field work with special emphasis on the foremen's attitude toward accident prevention.
Disobedience of specific instructions; violation of rules; horseplay	Check quality of supervision and suitability of supervisory employees; check rules to see that they are practical and that proper equipment and devices are available to make it possible for employees to follow them; determine if employees are working under pressure or are being pushed for extra production.

Accident Cause	*Corrective Action*
Inattention or lack of concentration	Check fatigue; check illumination; check presence of noises or other distractions.
Physical hazards	Check effectiveness of guarding and protection of live electrical equipment; check the causes of the poor housekeeping condition, lack of proper removal of waste material, and lack of proper cleanup procedure.
Defective equipment	Inspection of equipment before issue from tool room; periodic inspection of all equipment normally maintained in employees' kits or tool bags; instruction of employees in the proper care of equipment, including the turning in of defective equipment as soon as the defect appears.
Poor planning or design	Change of layout of machine or processes; redesign of equipment; provision of adequate aisles.
Unsafe building conditions	Structural redesign and repair.
Lack of proper personal protective equipment; improper dress or apparel	Provision of proper protective equipment and instruction in its use; enforcement of rules requiring the use of such protective equipment; in cases of unsuitable clothing, the possibility of the plant providing a suitable and specifically designed plant uniform may well be considered.

The statistical analysis of accidents by causes and sources is not in itself a complete job. It is simply the point at which preventive effort is geared to accident experience. Statistical analysis without correction is a waste of time. The entire point of cause-and-source analysis is lost if the accidents, once coded, lose their identity. This is too often the case.

The proper approach is: (1) analysis to determine the general fields in which preventive measures are required, (2) review and close study of the individual accident reports to determine the places and jobs thus demonstrated as requiring correction, and (3) a survey of other jobs to find similar weak spots at other points if they exist. Correction is based upon the results determined in this review and survey.

CHAPTER X

Layout and Arrangement

The planning of the layout and arrangement of a plant should be left to engineers and architects qualified in that field. However, there are certain fundamental principles of plant design which should be followed to provide the maximum in workers' safety. Therefore, the safety director should be given an opportunity to review the plans of the new establishment or of the renovations of an existing installation before they are finally approved.

The safety director or some member of his staff should be properly qualified by training and experience to review the plans critically in order to prevent hazardous conditions being built into the plant. Where large-scale construction is contemplated, it is usually necessary to assign a sufficient number of persons to the safety director's staff for this specific purpose.

In the larger plants, management demands that safety be built into the original design; however, in the small and medium-size plants, safety is seldom considered in the original design. One reason for this neglect is that many steps in the design and construction of a plant are taken individually and not planned in advance as a single project. The elimination of hazards, in the blueprint stage, is good management regardless of the size of the plant.

The initial design of any plant should at least incorporate the basic requirements for safe operation. The major considerations for layout and arrangement conducive to safety are outlined in the following sections. Several of these considerations are only mentioned briefly here, since they are discussed in detail in other chapters of this book. For fuller discussion of these matters, see the parenthetical references to other chapters.

Aisles. Adequate provision for aisle space and for the movement of materials through the plant should be provided. Too often the aisle space is that area remaining vacant after the machines are installed. For both efficiency and safety, the aisles should be laid out as carefully as the machine locations; in fact the machines should be placed around the predetermined aisles. Some of the most important considerations on this subject are:

a. If possible, vehicle aisles should be one-way and at least 2 feet wider than the vehicles they are to accommodate.

b. Where vehicle aisles are to be used for two-way traffic, they should be 3 feet wider than twice the width of the vehicles.

c. It is desirable to have walkways separate from the vehicle aisles; alternatively, bays, into which pedestrians can step out of the way of vehicles, should be provided.

d. Operations should be so arranged that materials move continuously in one direction. Eddies or backflows should be avoided.

e. Parallel operations should, if possible, be arranged in parallel banks to avoid piling up of traffic.

Storage Facilities. Intelligent planning should provide for the storage of raw materials, work pieces in process, and finished products. This may appear difficult, but it is a simple mathematical problem, provided the necessary ground work is done at the design stage rather than at the commencement of operations.

Two quantities of each item of raw material should be determined, the ordering point and the order lot. The first is the minimum stock, or the point at which a new lot must be ordered; the second is the economic quantity in which the material is to be purchased. The ordering point is determined on the basis of consumption of raw material, the rate of delivery, and the reasonable anticipated delays in delivery, plus an additional amount as a safety factor. The order lot depends upon the rate of use, the cost differential in large purchases, and the cost of providing storage. After these two quantities have been established, space should be provided for the safe storage of an amount of material equal to the sum of the two, or the maximum anticipated amount on hand at any time. Each material must be assigned its own space, sufficient for its maximum needs; to do otherwise means useless and expensive shifting of material from place to place, and increased opportunities for materials-handling accidents.

The amount of space required for the storage of work pieces in process of manufacture will depend upon the work schedule of the plant. In assembly-line plants, it should be theoretically possible to eliminate entirely in-process storage, as the entire line is geared to one pace. But even in this type of work, some storage is necessary so that a momentary pause in one place will not stop the line. In other types of plants, it is necessary to consider the time required for each step in process, the number of machines engaged in each step, and all other factors which influence both the building up and depletion of partially processed pieces. Frequently one machine must work an extra shift each day to maintain the production schedule; such a machine must have storage space behind it to accommodate the pieces upon which the extra shift will work and space ahead of it to accumulate the product of the extra shift. This space may also serve as room for expansion, since the slow machine is the one which must be duplicated in order to increase the plant output.

Storage of finished items must be geared to production and to economic shipping considerations. In most plants it is considered undesirable to build up an inventory of finished products, but in some industries of a seasonal character a large inventory is unavoidable. With all these conditions in mind, the relevant facts for the particular plant must be considered and a decision must be made as to the amount of space required.

Under no conditions is it permissible to store goods so high that sprinkler heads are blocked; nor should materials be piled in such a way as to block exits, fire-fighting equipment, or other emergency facilities. (Refer to Chapter II, " Handling Materials.")

Hazards of Falls from Elevations. Access to valves and to other controls more than 8 feet above the floor should be provided by permanently installed ladders. This avoids the necessity of obtaining and placing portable ladders, with all their attendant hazards. The permanent ladder should be designed with adequate clearance and with hand rails extending well above the platform level. Preferably such controls should be placed at lower levels, accessible from the floor, so that it would be unnecessary to use ladders. (Refer to Chapter IV, " Prevention of Falls.")

Hot Surfaces. Surfaces heated to a temperature in excess of 200 degrees Fahrenheit should be properly insulated, or provision should be made to prevent accidental contact by suitably placed screens or grills. All high-pressure steam-heating radiators should be so screened.

Guarding of Belts and Shafting. Belting and line shafting should be adequately guarded even when normally inaccessible. Horizontal belts over aisles and passageways should have, regardless of their height, a guard of suitable strength to prevent the belt from falling in case of failure. (Refer to Chapter XII, " Guarding.")

Low-Bridge Conditions. All vertical clearances should be checked to insure adequate headroom regardless of location. Head-striking hazards on stairs, protruding beams, columns, pipe lines, and similar equipment should be checked to insure adequate clearance above the floor or stair. Overhead platforms should be checked for clearance with regard to moving equipment, such as cranes and lorries, which may pass close enough to strike men working on the platforms.

Maintenance Operations. Adequate provision for the dismantling of plant equipment should be made for the safe performance of maintenance work, a factor often entirely overlooked in design. Suitable overhead cranes, eye bolts, lifting devices, walkways, and platforms should be provided, as well as space to accommodate the materials and parts while machinery is being dismantled or overhauled. Adequate and safe space should be available for the storage of equipment used in maintenance operation. The original design should include provision for reversing windows so that they can be cleaned from the inside or it should provide suitable and safe access for window cleaners while working on the outside of windows. (Refer to Chapter III, " Maintenance Problems.")

Outdoor Platforms. Overhead protection on loading platforms is often overlooked. This is a relatively inexpensive item which permits safe operation in bad weather and is, in addition, an important health consideration.

Locker Rooms, Washrooms, and Shower Rooms. The design of locker rooms, washrooms, and shower rooms should conform to these minimum requirements for accident prevention.

(a) Non-skid floors, probably of a slightly abrasive nature, to prevent falls by people who have wet or soapy feet.

(b) Grill protection on all radiators; all hot pipes insulated to a height of 8 feet above the floor.

(c) Lights high and out of reach; if less than 8 feet above the floor, they should be enclosed in vapor-proof fixtures.

(d) Key-type switch control of lights.

(e) No electric plugs of any kind permitted in the washroom.

(f) Benches attached solidly to the floor to prevent shifting or tilting; bench legs straight and completely beneath the bench area.

All other pieces of furniture upon which a man might stand are to be rigidly fixed to the floor.

(g) Large hot-water tank with quick recovery of temperature after draining. The outlet-water temperature should be regulated and controlled to a maximum of 120 degrees Fahrenheit. This can be done by limiting the tank temperature thermostatically or by equipping the tank with a cold-water connection and a regulator which thermostatically controls the temperature of the delivered water.

(h) Provide a double locker for each employee so that separate places are available for hanging street clothes and work clothes. This eliminates the need for piling work clothes on the locker floor where they constitute a fire hazard.

Ventilation. Provide proper exhaust and ventilating systems to insure an adequate supply of fresh air and to remove toxic materials or objectionable odors. In addition, this system should provide temperature control of air, and control of humidity. (The nature of the materials in process may itself require the installation of humidity control.)

Illumination. Artificial illumination should be planned, after the plant layout is completed, to give adequate lighting over aisles, working areas, storage, and all other space allocations. The artificial lighting must be designed to eliminate daytime glare and shadow, resulting from over-brilliance of sun-lit windows. (Refer to Chapter XI, " Illumination.")

Standards and Codes. Persons responsible for safety in the original design of equipment should familiarize themselves with the various standards and codes which are now available and apply them wherever necessary. These include the applicable regulations of the local, state, and federal governments, and the codes of the American Standards Association and of various technical societies. There are also many advisory pamphlets published by the National Safety Council. It should be remembered that these codes establish the minimum values and that in many cases it is considered desirable to exceed their requirements. (Refer to Chapter XXIV, " Standards and Codes.")

Facilities for First Aid and Medical Services. The original design should provide proper quarters for the administration of first aid to injured persons, and for the medical department if one is contemplated. Great care should be given to the proper location of such quarters. First-aid rooms should be centrally located with reference to the principal operations within the plant. In most cases it is desirable to locate the quarters for the medical department at a point remote from noisy operations and close to the plant offices in order to obtain the best conditions for treatment and to facilitate entrance examinations. The plant doctor should have a controlling voice in the location, space allotment, and layout of the quarters for the medical department. (Refer to Chapter XXI, " First-Aid Facilities.")

Expansion of Plant Capacity as a Factor in Original Design. Usually, at the time a plant is designed and built, some thought is given to probable expansion. Theoretically a plant can be expanded until every machine is used every hour of every day. If the production rates of the various machines are known, it is possible to determine how many of each will be required to give balanced production; that is, a condition in which each battery of similar machines produces in an hour the same number of processed units as each other battery of machines.

Practically, there is a limit to the expansion of a plant in the matter of labor. Evening work is considered less desirable than day work, and night work is so undesirable that, even when special bonuses are paid for it, workers generally try to avoid it. In consequence, only a part of the plant can be kept working two shifts a day, and a still smaller part three shifts a day. The reasonable contemplation of probable expansion of the plant would foresee expansion to the limit set by the distribution of the available labor market over the three shifts and would consider the slowest machines worked three shifts, the next faster group worked two shifts, and the fastest group worked only one shift.

It has been pointed out that the space provided in the original design for " in-process storage " can be considered largely available for expansion, since the expansion will, to some extent at least, reduce the need for such storage. These two factors must be jointly considered in the original design, and, to the extent that they overlap, the one which has the greater demand is the controlling consideration.

Renovation of an Existing Plant. The renovation of an existing plant presents an entirely different set of problems. Such a project usually implies an overall expansion of the plant within the same building. The hazard of overcrowding is present, and the resultant skimping on aisles, storage space, and other vital (but so-called non-productive) areas is almost unavoidable. Before such expansion is undertaken, a thorough investigation should be made of the possibilities of constructing either an annex, a duplicate plant, or an entirely new and modern plant.

It should always be remembered that crowding, whether of men or machines, is both dangerous and costly. In most cases, the argument against the creation of such conditions needs only to be intelligently presented to win the support of management.

Acquisition of a Plant Building. In most industrial expansions, the possibility of acquiring a new plant building is at least considered. There are three ways in which this may be done, each of which presents its own safety problems. These are: the purchase of an existing building with the intention of renovating it for plant occupancy, the construction of a building of standard design, and the construction of a building specifically designed for the use. Of these, the last is the preferred condition from the safety director's viewpoint since all special features can be incorporated in the design. However, the decision in most cases will be rendered on consideration of overall economy, and the safety director should at least be aware of the major economic factors so that he can direct attention to those which will help him obtain the type of design he wishes.

Purchasing an existing building usually appears attractive because such buildings are available at only a fraction of what they would cost to build. Cost to rebuild is no index of the value of a property. Its value is more accurately measured as the cost of a building less depreciation, less the cost of repairs and alterations, and less the evaluation placed upon any compromises either in regard to production, safety, or any other phase of plant activities. Any additional operating costs, resulting from such compromises or from increased fire insurance and similar charges, can be evaluated on the basis that an investment of from $6 to $10 is justified by an annual saving of $1. (The exact figure will depend on local conditions and can be determined for the plant location.)

If a new building is to be constructed for the plant, the safety director should have an opportunity to examine the plans so that he can suggest any modifications or additions which may be advisable in the interest of accident prevention. The elimination of potential hazards in the blueprint stage is a matter of little cost even if a standard design is being used; consequently there is little difficulty in securing a correction at this stage.

Work Flow. The modern plant, designed on a basis of an assembly line and of mass production, is an ideal type from the accident-prevention standpoint. Such plants are generally one story in height, with the final assembly proceeding in orderly fashion through a long, straight, shed-like building. Subassemblies are achieved in other sheds built at right angles to the final assembly building, each proceeding into the final assembly at its proper place. Such plants can only be built where adequate ground space is available, as in low-cost suburbs, primarily because of the amount of land required. For large cities, multi-story buildings with vertical arrangements of departments are usually necessary.

In any plant, whether it has one story or many stories, good production practice and safe work practices demand that the material in process flows smoothly and continuously from the start of the work to the finish. This requires that material should flow in one direction only, crossing of material flows or local eddying should be avoided, vertical lifts should be held to a minimum, parallel operation should be conducted along parallel lines of movement in so far as is possible, mechanical conveyors or gravity feeds should be used wherever feasible to eliminate trucking, and the rate of flow of all process equipment should be so regulated that excess stock of partly finished pieces at any point is avoided. The safety director can check these and other points of design to determine the existence of any violation of good practice.

There are two ways in which the necessity for vertical lifts can be limited to one lift. Raw materials may be lifted to the top floor and dropped from process to process by gravity feed, or initial processing can be done on the lowest floor and the partially finished pieces moved to the top floor from which all further moves would be by gravity.

Fire Hazards. The elimination of fire hazards in the plant should be given serious consideration in the design stage. Construction should be of fire-resisting or fire-retarding materials, adequate safe exits should be provided, and provision for the installation of the proper types of fire-fighting equipment should be included in the original design. (Refer to Chapter XV, " Fire Prevention and Extinguishment.")

Purchase of Equipment. Wherever possible, equipment should be purchased with guards designed and affixed by the manufacturer. Such guards are more satisfactory in every way than guards affixed after installation, and the total cost is less than for the patch-up job. To secure the purchase of adequately guarded equipment, the safety director must have the cooperation of the purchasing agent and should review the equipment specifications. (Refer to Chapter XII, " Guarding.")

The purchase of material-handling equipment, such as tractors, fork trucks, and floor cranes, should be closely supervised so that existing aisles will not be dangerously crowded. The maximum width of new trucks will be limited by the widths of the existing aisles.

General. The final survey of plans for any new establishment should be checked to ascertain that they include all the available modern devices for saving labor and preventing accidents, such as electrically operated doors, the use of the electric eye, remote-control operation of valves (or other heavy equipment located high above the floor), the use of interlocking devices, the installation of modern types of illumination, and the use of modern processes in the production of materials. Attention to these items at the time of the original design will insure efficiency of production, and health, comfort, and safety for the employees throughout the life of the plant.

REFERENCES:

National Safety Council's Safe Practices Pamphlet No. 103.

Reference Codes for Construction, American Standards Association.

Washroom and Locker Facilities No. B411, Metropolitan Life Insurance Company.

CHAPTER XI

Illumination

Sight is a photographic action of the eye in which light is converted to a mental impression that can be interpreted by the brain in terms of color, size, and shape. The physical laws that govern photography are fairly well known, but few persons, except those scientifically interested, are aware that the same rules apply to the use of the eye. Thus, it is well known that, in making a photograph, the required time of exposure is shortest when the light is brilliant, as in the case of the use of a photo flash bulb; identically, an object can be seen more quickly when brightly lighted than when dimly lighted. A brilliant source of light or a brilliantly reflected object within the photographed field will spoil a film by causing it to be light struck; identically, glare in the field of vision will distort the mental picture. Severe shadows around a photographed subject produce an unpleasant picture; identically, severe shadows in the field of vision are objectionable to the human eye. Detail cannot be faithfully reproduced in a photograph unless a good lens is used and properly focused upon an adequately lighted object; identically, an eye cannot reproduce detail accurately unless it has an optically good lens or one in which the faults are corrected, and then only when the object is properly illuminated.

In photography, it is possible to compensate for some conditions by altering some of the camera characteristics. A sensitive film can be used to produce good pictures in what could otherwise be insufficient light; a slightly defective negative can be improved by various tricks of development control and by retouching. The eye can compensate for defects in the field of vision in only two ways: by altering the eye lens through muscular effort, which produces strain, or by eyelid shading, which produces squinting.

Facts Relating to Sight. Certain basic facts relating to sight have been determined by scientific research and should be well understood before any attempt is made to evaluate an illumination problem. These are:

1. Seeing requires a definite time; the length of time required

decreases as the field of vision becomes more brilliant. To record fast motion accurately, brilliant illumination is required.

2. Young eyes are better than old eyes. Visual acuity progressively decreases as age increases, and visual defects are more frequent among older persons. Therefore, higher levels of illumination are required for older people than for younger ones doing the same type of work.

3. The human eye can see at almost any level of illumination by muscular strain; seeing at low levels of illumination or under conditions of glare or pronounced shadowing produces straining of the eye muscles.

4. Eyestrain produces fatigue and loss of efficiency in a short time, even in the course of a day's work. Over longer periods, it may produce visual defects.

5. Good illumination is conducive to plant cleanliness and good housekeeping. It also improves personal efficiency and plant morale.

6. Many accidents result, in part at least, from inability to see clearly and rapidly the approaching danger. Good illumination will decrease accidents by permitting full use of the warning senses.

Glare and Shadowing. It would be desirable to obtain exactly uniform illumination in every working area, but there must be sources of illumination which are of necessity brighter than the illuminated surface, and some degree of shadowing is unavoidable if solid objects, such as furniture, are placed in the lighted area. The human eye can accommodate reasonable variations in light intensity within its field of vision without strain, but, if the variations are extreme, the eye must strain to accommodate them by rapid muscular adjustment. For most eyes, the limit of reasonable variation has been determined to be approximately ten to one. If a light source is more than ten times as brilliant as the surface it illuminates, it produces glare; and, if it is in the field of normal vision, this glare is extremely objectionable and causes eyestrain. On the other end of the scale, shadowed areas which are illuminated at levels of less than one-tenth the illumination of the surrounding areas are also objectionable and cause strain.

It is improper to think of glare as being *excessive* light, and shadow as *inadequate* light, since both will frequently be found to exist in a single area. Neither glare nor shadow is in any way related to the amount of light; both are characteristics of *improperly distributed* light.

Both of these faults can be eliminated by proper design, producing more even distribution of the available light. Some of the characteristics of good design are the following.

1. The total light output should be achieved by installing a large number of small sources rather than a few large sources. This limits glare by reducing the brilliance of each source and tends to eliminate severe shadowing by supplying light from several sources at every point in the illuminated area.

2. Filament-type bulbs, unshaded, have high surface brilliance which will always prove glaring in contrast to the lighted area. Such bulbs should be enclosed in opalescent bowls of proper size, which, by spreading the light output over a larger surface, reduce the contrast to reasonable limits. Alternatively, in places in which high headroom is available, it is possible to effectively remove glare by hanging the bulbs high off the working surface and by shading them with proper reflectors. Such reflectors must be sufficiently deep to prevent viewing of the surfaces of bulbs at a distance from the person. Bulbs immediately overhead will be glaring if viewed but are out of the field of normal vision. Bulbs at a distance are at a comparatively low angle of vision if they are not cut off by reflectors and can produce objectionable glare since they are in the normal field. It should be understood that glare is not decreased by distance; while the total light thrown on the eye by a light source decreases as the distance increases, the apparent size of the object decreases in exactly the same proportion and the effective brilliance of the source is unchanged.

Opalescent bowls and reflector units are designed for bulbs of specific sizes. If larger bulbs than those for which the unit is designed are used, glare will be produced. In addition, trouble will be encountered, especially in the opalescent bowls, because of the inability of the fixture to dissipate the increased heat.

Fluorescent lamps have comparatively low surface intensities because of their large radiating surfaces. These may be used unshielded. In addition, since the light is spread over a considerable length of tube, light from a single unit will strike any surface from many points rather than one fairly concentrated spot, and harsh shadowing is unlikely.

Quantity of Light. The problem of determining the levels of illumination required for various tasks has been deeply studied by the American Standards Association, the Illuminating Engineering Society, and other organizations. A detailed table of minimum levels has been prepared by these groups and is included at the end of this discussion. It should be noted that these values are the minimum requirements. Higher levels are beneficial if they can be attained.

In many existing buildings, the rigid limitations of the sizes of the electric ducts built into the structure would prevent attaining these levels with filament-type bulbs. The development of fluorescent tubes has relieved this situation, since these units produce approximately three times as much light for the same power consumption. With this development, it is often possible to produce the required light without overloading circuits; in any case, the required level can at least be more nearly reached by the use of fluorescent units. The quantity of light may be measured by the use of simple light meters, which are commercially available. In many cases such meters can be borrowed from local utilities or other interested parties.

Color. White light is a combination of all the various colors. The composition of average sunlight is considered a standard white light. A satisfactory, approximately white light for most uses can be produced by a filament-type bulb or by a single white fluorescent unit. Where color definition is important, care must be exercised to produce a light which most closely approaches sunlight.

Filament-type bulbs produce a light which contains proportionately more red than is found in daylight. This excess of red can be removed by passing the light through a blue-tinted bulb. This is done in the daylight-type of filament bulb, which can be satisfactorily used for color comparison.

White fluorescent tubes produce a light which is much further from sunlight than that produced by normal filament bulbs. Consequently, when an installation of a number of fluorescent tubes is made, the white tubes are supplemented by tubes of various colors in fixed proportions to produce an approximate white. Where color definition is important, the normal assortment of white and colored tubes is inadequate and special devices must be employed, such as the addition of monochromatic (single-color light) sources, to make up the deficiencies.

Sunlight. Sunlight, while brilliant, is generally inadequate for plant lighting because of the glare and shadow produced by the widely varying levels of illumination. The level of illumination varies with the square of the distance from the windows or skylights.

Artificial illumination should be designed for the dual function of supplying night light and supplementing daylight in the otherwise dark parts of the rooms.

General Comment. Illumination, both natural and artificial, is a highly specialized function, and the original design should be checked by an illumination expert before it is installed. The safety director's duty in this field is primarily to detect faults and initiate the necessary steps for redesign and correction.

Maintenance of Electric-Lighting Efficiency. Dust on bulbs, reflectors, and opalescent bowls greatly decreases the light output. Light striking dust particles is in part reflected and in part turned into useless heat.

Walls and ceilings that are used as reflecting surfaces are parts of the lighting installation and, if allowed to become dirty, lose a part of their reflection characteristics. Dirty surfaces appear drab or gray because they reflect only a small part of the light thrown on them. In extreme cases, dirty walls and ceilings and dust accumulation on lighting-fixture parts have been found to cut down the illumination by 50 per cent; that is, half of the illumination was lost. Windows and skylights that are permitted to become dirty similarly lose a considerable part of their effectiveness as agents of natural lighting.

As an essential part of the illumination problem, windows and skylights must be periodically cleaned, lighting fixtures dusted or cleaned, and walls and ceilings cleaned or repainted. A reasonable schedule of such maintenance may be based upon performing necessary operations whenever the light output drops to 75 per cent of its initial value.

In places in which dust and dirt accumulate rapidly, the original installation should be designed to give, when clean, 50 per cent more light than is required for the work. If this has been done, the illumination may be permitted to drop to half its initial value (which corresponds to 75 per cent of the desired value) before cleanup is necessary.

All maintenance work on electric lighting circuits should be performed with the circuits switched off and with the maintenance men on wooden ladders.

RECOMMENDED MINIMUM STANDARDS OF ILLUMINATION FOR INDUSTRIAL INTERIORS

Prepared by the American Standards Association under the administrative leadership of the Illuminating Engineering Society. The numbers at the right are the minimum footcandles in service, measured 30 inches above the floor. These footcandle values represent order of magnitude rather than exact levels of illumination.

Assembly:	
Rough	10
Medium	20
Fine	B*
Extra fine	A*
Automobile Manufacturing:	
Assembly line	B*
Frame assembly	20
Body manufacturing, parts	20
Assembly	20
Finishing and inspecting	A*
Bakeries	20
Book Binding:	
Folding, assembling, pasting, etc.	10
Cutting, punching, and stitching	20
Embossing	20
Breweries:	
Brew house	5
Boiling, keg washing, and filling	10
Bottling	20
Candy Making:	
Box department	20
Chocolate department, husking, winnowing, fat extraction, crushing and refining, feeding	10
Bean cleaning and sorting, dipping, packing, wrapping	20
Milling	30
Cream making, mixing, cooking and molding	20
Gum drops and jellied forms	20
Hand decorating	50
Hard candy, mixing, cooking, and molding	20
Die cutting and sorting	30
Kiss making and wrapping	30
Canning and Preserving	20
Chemical Works:	
Hand furnaces, boiling tanks, stationary driers, stationary and gravity crystallizers	5
Mechanical furnaces, generators and stills, mechanical driers, evaporators, filtration, mechanical crystallizers, bleaching	10
Tanks for cooking, extractors, percolators, nitrators, electrolytic cells	15
Clay Products and Cements:	
Grinding, filter presses, kiln rooms	5
Molding, pressing, cleaning and trimming	10
Enameling	15
Color and glazing	20
Cleaning and Pressing Industry:	
Checking and sorting	20
Dry and wet cleaning and steaming	10
Inspection and spotting	A*
Pressing, machine	20
Hand	50
Receiving and shipping	10
Repair and alteration	50
Cloth Products:	
Cutting, inspecting, sewing, light goods	20

Dark goods	A*	
Pressing, cloth treating (oil cloth, etc.), light goods	10	
Dark goods	20	
Coal Tipples and Cleaning Plants:		
Breaking, screening, and cleaning	10	
Picking	A*	
Construction, Indoor:		
General	10	
Elevators, Freight and Passenger	10	
Engraving	A*	
Forge Shops and Welding	10	
Garages, Automobile:		
Storage, live	10	
Storage, dead	2	
Repair department and washing	30	
Glass Works:		
Mix and furnace rooms, pressing and lehr, glass blowing machines	10	
Grinding, cutting glass to size, silvering	20	
Fine grinding, polishing, beveling, etching and decorating	50	C*
Inspection	B*	C*
Glove Manufacturing:		
Pressing, knitting, sorting, light goods	10	
Dark goods	20	
Cutting, stitching, trimming, inspection, light goods	20	
Dark goods	A*	
Hangars — Aeroplane:		
Storage, live	10	
Repair department	50	
Hat Manufacturing:		
Dyeing, stiffening, braiding, cleaning and refining, light	20	
Dark	30	
Forming, sizing, pouncing, flanging, finishing and ironing, light	20	
Dark	30	
Sewing, light	20	
Dark	A*	
Ice Making, Engine and Compressor Room	10	
Inspection:		
Rough	20	
Medium	30	
Fine	B*	
Extra fine	A*	
Jewelry and Watch Manufacturing	A*	
Laundries	20	
Leather Manufacturing:		
Vats	5	
Cleaning, tanning, and stretching	10	
Cutting, fleshing, and stuffing	20	
Finishing and scarfing	30	
Leather Working:		
Pressing, winding, and glazing, light	10	
Dark	20	
Grading, matching, cutting, scarfing, sewing, light	20	
Dark	A*	
Locker Rooms	10	
Machine Shops:		
Rough bench and machine work	20	
Medium bench and machine work, ordinary automatic machines, rough grinding, medium buffing and polishing	30	
Fine bench and machine work, fine automatic machines, medium grinding, fine buffing and polishing	B*	
Extra fine bench and machine work, grinding, fine work	A*	
Meat Packing:		
Slaughtering	10	
Cleaning, cutting, cooking, grinding, canning, packing	20	

Milling, Grain Foods:	
Cleaning, grinding and rolling	10
Baking or roasting	20
Flour grading	30
Offices:	
Bookkeeping, typing, and accounting	50
Business machines, power driven (transcribing and tabulating) calculators, key punch, bookkeeping	B*
Conference room, general meetings	25
Office activities, *see* Desk work	
Corridors and stairways	5
Desk work, intermittent reading and writing	25
Prolonged close work, computing, studying, designing, etc.	50
Reading blueprints and plans	30
Drafting, prolonged close work, art, drafting and designing in detail	50
Rough drawing and sketching	30
Filing and index references	25
Lobby	10
Mail sorting	25
Reception rooms	10
Stenographic work	50
Vault	10
Packing and Boxing	10
Paint Mixing	10
Paint Shops:	
Dipping, simple spraying, firing	10
Rubbing, ordinary hand painting and finishing art, stencil and special spraying	20
Fine hand painting and finishing	B*
Extra fine hand painting and finishing (automobile bodies, piano cases, etc.)	A*
Paper Box Manufacturing:	
Light	10
Dark	20
Storage	5
Paper Manufacturing:	
Beaters, grinding, calendering	10
Finishing, cutting, trimming, paper-making machines	20
Plating	10
Polishing and Burnishing	20
Power Plants, Engine Room, Boilers:	
Boilers, coal and ash handling, storage battery rooms	5
Auxiliary equipment, oil switches, and transformers	10
Engines, generators, blowers, compressors	20
Switchboards	30
Printing Industries:	
Type foundries, matrix making, dressing type	A*
Font assembling, sorting	B*
Hand casting	30
Machine casting	20
Printing Plants:	
Presses	30
Imposing stones	A* C*
Proof reading	A*
Electrotyping:	
Molding, finishing, leveling molds, routing, trimming	B*
Blocking, tinning	30
Electroplating, washing, backing	20
Photo Engraving:	
Etching, staging	20
Blocking	30
Routing, finishing, proofing	B*
Tint laying	A*
Receiving and Shipping	10
Rubber Tire and Tube Manufacturing:	
Stock preparation, plasticating	20

Milling		20
Calendering		30
Branbury		20
Fabric preparation, stock cutting		30
Bead building		30
Tube tubing machines		20
Tread tubing machines		20
Tire building, solid tire		20
Pneumatic tire		50
Curing department, tube curing		B*
Casing curing		B*
Final inspection, tube		B*
Casing		A*
Wrapping		20
Warehouse		5
Mechanical Rubber Goods:		
Stock preparation, plasticating		20
Milling		20
Calendering		30
Branbury		20
Fabric preparation, stock cutting		30
Hose looms		30
Molded products		B*
Extruded products		30
Curing		B*
Inspection		A*
Boxing		20
Warehouse		5
Sheet Metal Works:		
Miscellaneous machines, ordinary bench work		20
Punches, presses, shears, stamps, spinning, medium bench work	20	C*
Tin plate inspection	B*	C*
Shoe Manufacturing (Leather):		
Cutting and stitching, cutting tables		20
Marking, buttonholing, skiving, sorting, vamping, and counting, light materials		20
Dark materials		50
Stitching, light materials		50
Dark materials		B*
Making and finishing, stitching, nailers, sole layers, welt beaters and scarfers, trimmers, welters, lasters, edge setters, sluggers, randers, wheelers, treers, cleaning, spraying, buffing, polishing, embossing, light materials		30
Dark materials		50
Storage, packing, and shipping		10
Shoe Manufacturing (Rubber):		
Washing, coating, mill run compounding		10
Varnishing, vulcanizing, calendering, upper and sole cutting		30
Sole rolling, lining, making, and finishing processes		50
Soap Manufacturing:		
Kettle houses, cutting, soap, chip, and powder		10
Stamping, wrapping and packing, filling and packing soap powder		20
Stairways, Passageways		5
Stone Crushing and Screening:		
Belt conveyor tubes, main line shafting spaces, chute rooms, inside of bins		5
Primary breaker room, auxiliary breakers under bins		5
Screens		10
Storage Battery Manufacturing:		
Molding of grids		10
Store and Stock Rooms:		
Rough bulky material		5
Medium or fine material requiring care		10
Structural Steel Fabrication		10
Sugar Grading		30

Testing:	
Rough	20
Fine	30
Extra fine instruments, scales, etc.	A*
Textile Mills (Cotton):	
Opening, mixing, picking, carding, and drawing	10
Slubbing, roving, spinning	20
Spooling, warping on comb	20
Beaming and slashing on comb, gray goods	20
Denims	B*
Inspection, gray goods (hand turning)	50
Denims (rapidly moving)	A*
Automatic tying-in, weaving	B*
Drawing-in by hand	A*
Weaving	25
Silk and Rayon Manufacturing:	
Soaking, fugitive tinting, and conditioning or setting of twist	10
Winding, twisting, rewinding and coning, quilling, slashing	30
Warping (silk or cotton system) on creel, on running ends, on reel, on beam, on warp at beaming	50
Drawing-in, on heddles	A*
On reed	A*
Weaving, on heddles and reeds	10
On warp back of harness	20
On woven cloth	30
Woolen:	
Carding, picking, washing, combing	15
Twisting, dyeing	15
Drawing-in, warping	A*
Weaving, light goods	25
Dark goods	50
Knitting machines	20
Tobacco Products:	
Drying, stripping, general	10
Grading and sorting	A*
Toilets and Wash Rooms	10
Upholstering, Automobile, Coach Furniture	20
Warehouse	5
Welding	30
Woodworking:	
Rough sawing and bench work	15
Sizing, planing, rough sanding, medium machine and bench work, gluing, veneering, cooperage	20
Fine bench and machine work, fine sanding and finishing	50

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* Lighting recommendations for the more difficult seeing tasks, as indicated by A, B, and C in the foregoing table, are given in the following:

Group A:

These seeing tasks involve (a) the discrimination of extremely fine detail under conditions of (b) extremely poor contrast, (c) for long periods of time. To meet these requirements, illumination levels above 100 footcandles are recommended.

To provide illumination of this order, a combination of at least 20 footcandles of general lighting plus specialized supplementary lighting is necessary. The design and installation of the combination systems must not only provide a sufficient amount of light but also must provide the proper direction of light, diffusion, eye protection, and insofar as possible must eliminate direct and reflected glare as well as objectionable shadows.

Group B:

This group of visual tasks involves (a) the discrimination of fine detail under conditions of (b) a fair degree of contrast (c) for long periods of time. Illumination levels from 50 to 100 footcandles are required.

To provide illumination of this order a combination of at least 20 footcandles of general lighting plus specialized supplementary lighting is necessary. The design and installation of the combination systems must not only provide a sufficient amount of light but also must provide the proper direction of light diffusion, eye protection, and insofar as possible must eliminate direct and reflected glare as well as objectionable shadows.

Group C:

The seeing tasks of this group require the discrimination of fine detail by utilizing (a) the reflected image of a luminous area or (b) the transmitted light from a luminous area.

The essential requirements are (1) that the luminous area shall be large enough to cover the surface which is being inspected and (2) that the brightness be within the limits necessary to obtain comfortable contrast conditions. This involves the use of sources of large area and relatively low brightness in which the source brightness is the principal factor rather than the footcandles produced at a given point.*

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*Table and explanatory notes extracted from the booklet *American Recommended Practice of Industrial Lighting,* by permission of the American Standards Association and the Illuminating Engineering Society. For further information on the subject of illumination, refer to that booklet.

CHAPTER XII

Guarding

Statistically it can be demonstrated that a great majority of accidents are the direct results of people's faults; that is, most accidents result from human failings. This is occasionally used by plant management as an argument against the safety director's proposal for the guarding of equipment, especially with respect to specific accidents where the human fault is very apparent.

An understanding of the basic difference between accident cause and accident source will aid greatly in overcoming this type of resistance. While it is claimed that few accidents are caused by the lack of proper guards on machines, it can be demonstrated that machines are the source of about 10 per cent of the injuries resulting in fatalities and permanent total disabilities, and of almost 25 per cent of the injuries resulting in permanent partial disability. Most of the accidents traced to the machinery source can be controlled by the installation of adequate guards. Good safe-guarding of equipment is positive accident prevention in that it completely eliminates the chance of human failure causing an injury by contact with moving parts of the machine. It should be thoroughly understood that a guard must be effective to be good and that, if it is not good, it should not be in existence. The installation of proper guards demonstrates to the employees management's real interest in accident prevention and, in consequence, spurs employee interest.

In most states it is the legal responsibility of the employer to furnish proper guards for the protection of his employees, but the definition of proper guard is usually omitted. Furthermore, most states provide that, if a guard is removed for a necessary maintenance operation, it is the joint responsibility of the maintenance foreman, production foreman, and plant management to see that the guard is replaced before the machine is returned to normal operation. In this respect the safety director's responsibility is two-fold: first, to see that the machines are purchased with proper guards or subsequently provided with proper guards; second, to insure that such guards are used during operation of the machine. In order to be able to execute these functions, the safety director must have a fundamentally sound concept of what constitutes a good and adequate guard and of the methods of operation of the machines that are guarded. An ineffective guard often makes the original hazard more dangerous by creating in the mind of the operator a false sense of security.

General Requirements for Good Guarding. The general requirements for good guarding of machines are as follows.

1. The guard must effectively protect employees from a pre-existing hazard.
2. The guard must be sufficiently substantial so that, if the guarded part breaks, the fragments will be contained within the guard. (There is an exception to this rule in the case of flywheel guards, which cannot in any case be constructed to meet it.)
3. The guard must not introduce any new hazards of its own; thus it must not offer any sharp corners to cause injury to the employee in passing. It must not introduce tripping hazards or unnecessary striking hazards.
4. The guard must not obstruct the controls of the machine.
5. The guard must not interfere with any proper or legitimate operation of the machine.
6. The guard must be so designed as to permit normal everyday maintenance operations, such as oiling and greasing, without requiring the removal of the guard.
7. The guard must be removable for major maintenance; when disassembled, it should not be too difficult to reassemble. In so far as is possible, there should be no small removable parts.
8. The guard must not weaken the construction of the machine. In affixing the guard to the machine, no part that is of critical strength should be disturbed.
9. In addition to these necessary requirements the guard should be made preferably of either sheet metal or expanded metal. Exceptions to this preference are the cast iron guards, such as are used around gears, and wood or plastic where certain chemicals make them desirable.

Construction Details. The guard must be so constructed that fingers or hands of the operator cannot be inserted into the machinery through the openings in the guard. Thus, if expanded metal is used for the guard material, the size of the opening should be not greater than ¼ inch in the smaller dimension and ⅜ inch in the larger dimension if the guard is to be within 4 inches of the moving part. If the guard is at a distance greater than 4 inches away from the moving part, the openings should not exceed 2 inches in either dimension. (Expanded metal guards are generally constructed on light angle framework to give them the necessary strength.)

In sheet-metal guards, windows must be provided at all points requiring frequent visual inspection. These windows may be wired glass, plastic, or expanded metal inserts. If it is necessary to provide small openings for oiling or similar everyday maintenance, these openings must be protected by metal discs permanently mounted on the main body of the guard and so arranged that they can be moved out of the way for oiling without being detached from the guard. Shoulder rivets are frequently used to provide this type of mounting. In the design of the guard it is preferable to have the covers of such openings fall back into the closed position under the action of gravity to insure their closure.

Plastics may be used for guard materials provided they are sufficiently strong for the purpose and provided none of the lubricants or materials used in the process are destructive to the plastic.

Part of Machine Requiring Guarding. Any part of the machine that may cause injury upon contact should be guarded to prevent such contact. The ordinary points that require guarding on any machine fall into two categories: the system of power transmission, and the point of operation.

Power-transmission guarding is defined as the guarding of all moving parts of equipment used in the mechanical transmission of power, including prime movers, intermediate equipment, and driven machines, and excluding the point of operation. This definition includes such devices as gear trains, belting and shafting, rotating parts, shaft ends, and similar hazards.

The point of operation of the machine is the place at which the power is applied to a tool that in turn is brought to bear against the work piece to cut, drill, punch, or otherwise operate upon it.

Power-Transmission Guarding. The following are suggested as the minimum requirements for the guarding of power-transmission equipment in any plant.

All gear trains should be fully enclosed. Enclosure prevents personal-injury accidents which might otherwise result and, in addition, permits the operation of the gear train in oil, which reduces wear on the gears, eliminates noise, and will remove other bad characteristics from the operation. Gear-train enclosure prevents destruction of the gears by accidental insertion of wood or metal objects between the gear teeth.

The standards established by the power transmission code are suggested as the minimum requirements for the guarding of belting and shafting. In most states these standards are a legal requirement. These requirements are:

a. All horizontal belts and shafting within 8 feet of the floor shall be guarded.

b. Horizontal belts over passageways (regardless of their height) shall be guarded.

c. That portion of vertical belt extending 6 feet above the floor shall be guarded.

Most plants voluntarily exceed these limits. Safety directors in most plants advocate much more liberal application of guarding of belting and shafting. However, no general rule can be specified as the one most normally employed; in every case the safety director's ultimate objective is to provide complete guarding of all shafting and belting.

Rotating parts should be guarded, by location or by specific machine guards, against the hazard of accidental injury resulting from contact. Any projections from the smooth rotating surface should be eliminated. Set screws, if required, should be countersunk below the smooth surface of the rotating part. All rotating parts should be round rather than any other geometric shape.

All rotating shaft ends should be protected by simple cup guards. If it is necessary to take tachometer reading at a shaft end, the cup guard should be provided with a proper opening for this operation.

Point-of-Operation Guards. The point of operation is potentially the most hazardous part of a machine. It is here that the entire force and movement of the machine is converted to an ability to tear, grind, cut, or shear metal or wood. Even on a small machine, because of the power concentrated here, the point of operation is readily capable of inflicting amputation or other serious injuries upon human flesh if contact is permitted. Unfortunately guarding is omitted at the points of operation more frequently than at any other point of comparable danger on machines.

The principal specific dangers involved in the hazard at the point of operation are the feeding and stripping of work pieces, reaching into the work area during operations, neglecting to use proper holding devices for the work, and improper clothing. Machine guarding at the point of operation should contemplate these specific hazards and should, in so far as is possible, eliminate them completely. On the matters of neglecting to use proper holding devices and proper clothing, guards must, of course, be supplemented by proper employee training.

Many machine accidents result from an effort to speed the work unduly, which in turn may be the result of the pressure of work or of the desire to have free time for recreation. Accidents of this type can be controlled by study of plant conditions and corrective action based upon that study to eliminate the causes of hurry.

Reaching into the zone of operations is a thoughtless act, often resulting from an instinctive desire to prevent an improper operation of the machine. This type of action is one that it is almost impossible to eradicate by training or a similar device, since in most cases it occurs before the worker can think. In contrast to these many varied methods of reducing machine accidents, guarding the point of operation properly eliminates all causes of such accidents.

It may be stated that the ideal machine is one in which all operations are performed automatically under operator supervision. Such a machine would provide automatic feeding of the work pieces, automatic stripping after the completion of operation, setting of tools by remote control, and many similar conditions. When such a condition can be achieved on any machine, the entire working area of the machine can be included within an enclosure-type guard so constructed that it will prevent access to the work area during operation and, when opened, will shut off the source of power to the machine so that machine hazards effectively cease.

Unfortunately the cost of setting up a machine to work as automatically as would be ideal is so high that it is impossible to attain this condition in any but long-run, repetitive operations. It must be anticipated that, in any plant, some machines will necessarily be fed and stripped manually. In most small plants that do general work, it is probable that all the machines will be manually fed and stripped. Therefore, in a discussion of guards for the point of operation, it is customary to assume manual-type operation and to consider the devices which can be used to make manual operation safe. These devices fall into six general classes which are as follows.

1. *Guarding built into the machine.* Many modern machines are built in such a way that it is impossible for the operator to reach into the zone of operation. In this way the construction of the machine itself safeguards the worker from injury. A specific example of this type of protection is the punch press in which the opening provided for the admission of the work piece below the punch is a horizontal slot not greater than $\frac{3}{8}$ of an inch in height; this slot provides the only access to the punch and, since it will not admit the operator's fingers, affords positive protection. With the exception of punch presses designed for use in the structural steel industry, few will work stock heavier than $\frac{3}{8}$ of an inch in thickness. Therefore, a guard of this type does not in any way limit the capacity of the machine.

In punch presses of older design, it was customary to expose the rams over their entire travel. As these rams must travel a considerable distance to attain the required momentum, the older machines have large exposed areas beneath their rams, which are not necessary for operation. These machines can frequently be protected by the addition of fixed guards limiting access to a $\frac{3}{8}$-inch slot.

2. *Gate guard.* The point of operation may be protected by an enclosure or cover into which is built a gate. The gate may be opened to permit access to the point of operation for feeding, stripping, and other required purposes. Protection is afforded by interlocking the gate with the driving mechanism so that, when the gate is opened, the operation of the machine will immediately cease and (if necessary because of the momentum of parts) a brake will be applied.

Gate interlocks should never be used as a means of starting or stopping the machine, since this abuse will unduly wear and pit the control-circuit contacts and eventually cause them to stick and operate improperly.

3. *Electric eye protection.* The electric eye is a common name for a device consisting of a control beam from an electric-light source pointed at a light-sensitive (selenium) cell. If the beam is broken by any object passing between the source and the cell, the electrical resistance of the cell changes immediately. The cell is connected in a live circuit with a proper relay, and the change in resistance causes the current through the circuit to change. The relay, detecting the change in current, operates; this operation can be used either to make or break an electrical circuit.

Electric-eye devices are commonly used in many functions other than machine guarding; for example, they are frequently employed as door-operating devices in such places as garages, restaurant kitchen doors, and similar applications.

As machine guards, electric eyes are installed around the point of operation of a machine in such a way that, if the operator's hand is put into the machine, power is immediately cut off, the operation ceases, and a brake is applied, if required, to stop the machine quickly. The electric eye must completely cover the opened area so that access to the point of operation is completely controlled.

4. *Sweep guard.* A sweep guard is a mechanical device consisting of an arm connected to the machine in such a way that the arm sweeps over the point of operation just before the operation begins, pushing the operator's hand out of danger.

Sweep guards are often ineffective because their construction permits the operator to reach into the point of operation after the sweep has passed. Therefore they do not afford positive protection; however, they are helpful in diminishing danger on feeding and stripping operations.

5. *Harness guards.* A harness guard consists of wristlets connected through a pulley system so that, just before the machine operation commences, they will pull the wearer's hand away from the point of operation.

Harness guards can be rigged simply and inexpensively on almost any machine in which acute hazard exists at only one part of the machine cycle, as is the case in most punch-press operations. These guards furnish positive protection to the operator if frequently inspected and maintained.

Objection is often made to harness guards on the psychologic ground that they damage employees' morale, since they make the operator a piece of the machine he operates instead of its master. The value of this objection will depend upon the nature of the operator. Harness guards have been found satisfactory in many cases, while in other instances they have developed so much employee resentment that they became a source of considerable trouble.

If harness guards are used, care must be taken that they do not force the employee's arm into an unnatural or uncomfortable position.

6. *Dead man controls.* Controls which must be continuously held in engagement during operation, and which, if released, im-

mediately stop the machine, are called dead man controls. They have two beneficial results: they force the operator to continuously stay at the machine, and they keep the hands of the operator at safe locations during operations. They may be so built as to require either one-hand operation or two-hand operation depending upon whether the operation is completely automatic once it is started or whether the operator is required to use one hand to manipulate a control on the machine. Thus, on a drill press, where the operator is required to control the penetration of the drill by his right hand, a dead man control may be so placed that his left hand must continuously be pressing upon it during operation. In this way the left hand is kept continuously out of the danger area.

If double dead man controls are to be installed, they must be so constructed that one control cannot be voided. If simple controls are employed, it may be found that employees will void one control by placing a weight upon it to hold it continuously depressed or by some similar arrangement. Improper operation of this type effectively voids the protection otherwise afforded. In order to be effective, double dead man controls must be placed sufficiently far apart so that both hands will be required to work them; they must be so located or so shielded that the operator cannot manipulate one by pressing against it with his body or thigh; and they must be so constructed that both must be depressed at the same instant in order to cause the machine to operate.

Partial Safeguards. Many devices have been developed to eliminate some of the improper machine operations and unsafe acts which most frequently cause accidents. These are partial safeguards, effectively eliminating certain mechanical failures which may cause injury, but not eliminating the opportunity for human-failure accidents. They are valuable additions to proper machine guards and in many cases are found to be worthwhile where the cost of properly guarding the machine is thought to be prohibitive. However, none of these devices in itself can be classified as positive guarding.

One of the commonest partial safeguards is the non-repeat device type which prevents a machine from starting a second cycle of operations until the operator is ready. The single-stroke clutch is an excellent example of this type. When the clutch is depressed, the machine controlled by it will go through one complete cycle of operation, after which the clutch automatically disengages. The machine will not operate again until the clutch has been released and depressed a second time.

On machines in which the operator may be drawn into pressure rollers, release bars or cables are frequently placed just in front of the rollers. If the operator becomes entangled in the equipment, the simple act of striking the release bar will remove the pressure from the rollers and may also stop their rotation. Thus, the severity of the injury inflicted is limited.

Color contrast is frequently employed to improve visibility of the work process. This is a great aid to the machine operator in avoiding injury from the inherent hazards of the operation. Machine beds, and other stationary parts, are painted in light colors so that the work tool and the work pieces stand out by contrast. Several of the larger paint manufacturers have developed color contrast to a point approaching scientific accuracy and will, upon application, give free consultive service.

On completely automatic operations, stop switches can be placed at strategic locations so that, if injury to a worker or a machine is imminent, the operation can be stopped instantly by another person. This form of protection is almost universally employed on conveyors and other automatic transportation devices.

Other common partial safeguards are shields over controls that prevent operation of the machine through accidental tripping, lock switches that prevent operation by unauthorized persons, and door locks that prevent access of unauthorized persons to such hazardous locations as electric switchboards and crane walkways.

Flywheel Guarding. In general it is physically impossible to design guards strong enough to prevent fragmentation of flywheels in the event such wheels explode under centrifugal force. Particular attention must, therefore, be given to eliminating the causes of flywheel explosion.

In segmental flywheels an explosion may result from failure of the bolts that hold the segments together. Such failures are usually caused by fatiguing of the bolt material. This can be prevented by periodically removing and heat treating these bolts; this treatment should be given at least every five years.

A common cause of flywheel explosion is overspeeding of the device which drives the flywheel. The tendency to explode is directly related to the speed at which the flywheel operates, and overspeeding will tear a flywheel apart. The overspeed hazard is especially prominent where a direct-current motor or a prime mover, such as a steam engine or gasoline engine, is used as a power source. If the flywheel is directly connected to a load, the characteristics of that load may, in themselves, effectively prevent overspeeding of the device; in such cases the chance of flywheel explosion is extremely slight. Thus a direct-current motor directly connected to an air compressor cannot overspeed because the compressor itself would act as a brake; in this case the flywheel interposed between the motor and the compressor cannot overspeed and therefore does not have to be protected from this danger.

Where the danger of flywheel overspeed exists, devices should be provided to put a safe limit upon the maximum speed at which the flywheel can operate. Full dependence cannot be placed upon the governors of the drive mechanism which may themselves become defective. The overspeed devices should be quick and positive in response and should be frequently checked by a safe test procedure (which does not countenance the danger of machine overspeed) in order to assure that the device will operate satisfactorily in an emergency.

Flywheels driven by alternating-current motors of the synchronous or induction types are protected by the characteristics of the driving motor and cannot overspeed. Such flywheels do not require specific overspeed protection.

Steam turbines, unless prevented from overspeeding by the characteristics of direct connected load, should also be provided with overspeed protection since the blade wheels are subject to the risk of fragmentation at excessive speed.

In considering the need for overspeed protection on any flywheel or other large rotating device, the safety director should consider the normal conditions of starting, normal operations, and stopping, and such unusual conditions as may arise in any of these. As an example, rotary converters, which in normal operation are tied to synchronous sources and cannot overspeed because of that tie, are generally started as direct-current motors and may overspeed during the starting operation if the field excitation circuit is broken. For this reason overspeed devices are usually provided on rotary converters.

Objections to Guarding. Piece workers occasionally object to machine guarding because they feel that the guards slow production. Actually the installation of proper guards will increase the speed of work since they eliminate the distraction of requiring the employee to avoid unguarded, known hazards.

Management occasionally objects to guarding, considering it as unwarranted expense. This objection can be met intelligently by demonstrating the cost of past accidents (including indirect elements of cost) which resulted from improper or inadequate guards and by the demonstration of the increased operating efficiencies resulting from the use of proper guards.

Floor Openings. Permanent floor openings should be protected by either angle iron or pipe railing. Two rails are required, the top rail not less than 3 feet 6 inches from the floor, and the second rail intermediate between the top rail and the floor. A toe board not less than 4 inches high is recommended.

Abrasive Wheels. Abrasive wheels should be installed and operated in accordance with the American Standards Association Code on this subject. The most important items concerning their installation are the following.

The enclosing hood should be of adequate strength to hold the fragments if the wheel burst. The hood opening should not be greater than 125 degrees. When a work rest is used, it should be securely mounted and shaped to fit the contour of the wheel and adjusted to a maximum distance of 1/8 inch from the wheel. Flanges used to hold the wheel in place should be of proper size and fit. The wheel should be mounted centrally, thoroughly secured, and free from vibration. The speed of operation should be within the code limit. In no case should an oversized wheel be used because the speed limit will be exceeded.

Abrasive wheels, while in storage, should be very carefully treated to prevent initial fault. They should be protected from shock, dampness, oil spots, or any other injury which might damage them or throw them out of balance when installed for use.

The operator of a grinding wheel should be protected by suitable goggles. An adjustable shield should be used in addition to the goggle protection.

Automatic Machinery. Since guarding consists of enclosing moving parts, a completely enclosed unit that performs an automatic operation represents an ideal condition of guarding. Human fault cannot cause a machine accident on a completely enclosed unit. Any fully automatic operation can be thoroughly enclosed to eliminate all chances of contact with moving parts. The prime objective of the safety engineer is to work towards automatic operation of all equipment, especially on accident-breeding work.

Management may object to automatic machinery because of high initial cost. However, increased production, greater efficiency, and freedom from accident are all factors to be considered in estimating the worth of the machine. In many cases it will be found that these advantages justify the purchase of the more expensive automatic machine.

Design of Machine Guards. This chapter has attempted to explain in a general way the requirements of good machine guarding and the points on a machine or other mechanical devices which require guarding. It would be impossible to include a complete discussion of the actual design of machine guards since this subject is in itself a very broad one requiring knowledge of available materials, the specific operations of the machine to be guarded, and detailed knowledge of the plant set-up in general.

For specific information on the design of guards for equipment, the reader is referred to the following sources:

1. *Suggested Standards for Industrial Safeguards, Special Bull. 7,* United States Department of Labor, Division of Labor Standards. (Available from Superintendent of Documents, Washington, D. C., price 65c.)
2. *Safety Code for the Use, Care, and Protection of Abrasive Wheels.*
3. *Safety Code for Mechanical Power Transmission Apparatus.*
4. *Handbook of Industrial Safety Standards,* National Conservation Bureau, 60 John Street, New York, New York.

CHAPTER XIII

Electrical Conditions

Electricity is a form of energy which can be conveniently transmitted over long distances and which can be converted to any of the other forms of energy. This ease of transmission and conversion has made electricity the basis for most domestic comforts and industrial conveniences which characterize and benefit modern life.

Electricity has been an outstanding boon in the field of industrial-accident prevention. It has made artificial lighting possible at levels sufficiently high for safety. In the line of power drives, it first eliminated the steam engine or other prime mover from the average industrial plant, later removed the belting and shafting associated with common drive, and substituted safe and simple individual drives in their places. In addition to these major contributions, electricity has found many uses in such safety operations as interlocking devices, electric-eye guarding, automatic feed, and similar safeguards.

Along with its useful features, electricity has certain harmful characteristics if misapplied or improperly controlled. As an energy form, it can produce a shock to the human body which can prove fatal. Converted into heat, electricity can cause painful or even fatal burns. Converted into brilliant light, it can damage the human eye. But the conditions under which any of these harmful effects are created are so well defined that they can be prevented readily. In fact most cases of electrical injury result from the willful or ignorant removal of various means of protection provided to prevent such injury. A sound knowledge of the possible ways in which electricity can injure the body is a requisite to the proper appreciation of the need for adequate protection and is a most practical basis for electrical-accident prevention.

ELECTRIC SHOCK

Electric shock is a term applied to all effects of the passage of electric current through the body except those resulting in burning or other chemical changes of the tissues. The nature and severity of the shock depend upon the parts of the body that carry the current and upon the amount of current and the length of time during which it flows. Alternating current and direct current are distinctly different in their shock effect. It has been determined experimentally that shock depends on current value and not on voltage; of course, it should be understood that the voltage applied and the resistance of the body circuit together determine the current that will flow through the body.

A current path existing between two points on the same arm will not produce lethal shock; similarly a current path from one leg to the other will not produce lethal shock. In either of these circuits, if the current is large, severe burns may result. In the leg-to-leg circuit, which may include current passage through vital abdominal organs, those organs can be sufficiently damaged by large currents to cause death.

Circuits that cause current to pass through the torso in the neighborhood of the heart, and those that include the brain or parts of the central nerve system, are likely to produce fatal shock. Experiments with anesthetized animals have demonstrated that circuits established between the two forelegs, between one foreleg and one hind leg, between head and any leg, and between chest and back are about equally dangerous at any current value. Circuits from one side of the chest to the other are dangerous at low current values but apparently do not produce as dangerous shock at high current values. In fact, currents in the neighborhood of twenty-five amperes, passed from chest to chest for extremely short periods of time, have been used successively to resuscitate animals from fibrillating shock.

The electric resistance of the body is concentrated chiefly in the skin tissues at the points of skin contact. The resistance of the skin varies greatly; when the skin is thoroughly wet with perspiration or water, or if it is cut or blistered at the points of contact, the resistance of the body may be as low as 1,000 ohms. Skin that is dry and clean at both points of contact is sufficiently resistant to increase body resistance to the neighborhood of 100,000 ohms. Dry, clean skin offers little additional protection because the passage of even slight current causes local sweating, blistering, or charring of the tissues and almost instantaneously reduces body resistance to the lower value. For this reason any contact with circuits operating at or above 500 volts, even under conditions of dry skin, is likely to produce fatal or asphyxiating shock; contacts with voltage as low as 75 volts may produce fatal shock under certain skin conditions. The lower values of current flow that may prove damaging to men have been determined with reasonable accuracy by experiments on them (in the range of currents that can be applied safely under controlled laboratory conditions) and on sheep at higher currents. Conclusive experiments at high current values apparently have not been possible because of the effects of the anesthetics under conditions of asphyxiating shock. It is felt that the effect of electric current on sheep is approximately the same as the effect on adult men of average build, about 150 pounds in weight. The effect of current apparently varies considerably with body weight, so that smaller currents would produce the same damaging effect in average-sized women, in children, and in small men. The effects of current apparently vary with individuals; therefore, the current ranges are indicated rather than average values.

The injuries inflicted on adult males in contact with alternating-current circuits may be anticipated to adhere to the following pattern.

Currents of 1/100 to 2/100 ampere cause muscular contraction that prevents the individual from freeing himself from contact. No serious effects are likely to result from the shock itself, but fear or other psychological factors may produce severe injury.

Slightly higher currents, probably in the neighborhood of 1/40 ampere, extend the contraction of muscles to the chest and make breathing difficult or impossible. If such currents endure for several moments, they may produce asphyxiation because of the lack of oxygen.

Currents in the range from 1/10 to 1/25 ampere, endured for ¼ second or longer, produce heart fibrillation. The tendency to fibrillation increases as the current flow is increased to about twice the minimum value required to fibrillate the individual. Further increase of current decreases the tendency to fibrillate, and currents greater than four times the minimum value for fibrillation have little tendency toward causing fibrillation.

On circuits enduring for an interval of an extremely short time (less than ¼ of a second), the current range required for fibrillation is 2 to 5 amperes. These currents, to produce fibrillation, must be induced at such a time that they coincide, in part at least, with the partially refractory phase of the heart cycle; this phase covers approximately 1/5 of the entire cycle. The effect of increase of currents of such short duration is proportionately the same as for the currents of longer duration described above. Most accidental contacts with electric circuits will exceed the 1/4-second duration; however, in laboratory work it may be possible to interrupt circuits with sufficient speed to take advantage of the increased personal safety resulting from limitation of the shock endurance.

Currents of higher value (probably 2 to 3 amperes or greater, enduring for more than 1/4 of a second) may produce asphyxiation by breathing paralysis. Extremely high currents (25 amperes for less than 1/4 of a second) have been used successfully to stop fibrillation of the heart in sheep, after fibrillation had been set up by the passage of smaller currents. The current path in these cases was rigidly controlled to prevent damage to the central nerve system or burning of vital organs. As yet there is no practical application of this fact in the resuscitation of human victims.

The injuries resulting to adult males on contact with direct-current circuits may be anticipated to adhere to the following pattern.

Muscular contraction is negligible in direct-current contact except when the current value changes rapidly, as in making or breaking the contact. Direct current flowing through the body produces a sensation of burning along the current path. At about 1/14 ampere this sensation is unbearably painful but is not damaging to the tissue. Higher currents produce greater pain but are not likely to produce serious burns until excessive current values are reached. Fibrillation appears in the range of 1/2 to 2 amperes on contacts longer than 1/4 of a second and in the range from 2 to 5 amperes on shorter contacts occurring during the partially refractory phase of the heart cycle. It is believed that the effect of high current values would be proportionately the same as on alternating-current circuits, but this field has not been sufficiently investigated by experiment to permit the drawing of conclusions.

In cases of asphyxiation resulting from muscular contraction or breathing paralysis, there is an excellent chance that artificial respiration, promptly applied, will prove successful. In cases involving fibrillation of the heart, artificial respiration produces massage action that stimulates circulation and may cause the heart to resume normal activities, although the chance of such successful treatment is small. In any case of electric shock it is impossible to determine which shock condition has been established in the body, and artificial respiration should be promptly applied as the only available means of possible resuscitation.

It is possible that, in the future, means may be developed for the prompt diagnosis of fibrillatory conditions and that safe counter-shock equipment may be developed; however, under present conditions it is not recommended that attempts at resuscitation by counter-shock be countenanced because of possible infliction of further damage to the body of the shocked victim.

PREVENTION OF ELECTRIC SHOCK

Prevention of electric shock is divided into two methods of operation: limitation of the circuit current to values less than one-tenth of an ampere, and isolation of the electrical circuit and its component parts so that contact of a person with it is difficult or impossible.

The first of these methods is limited almost completely to the field of static-eliminating devices on machines, and to laboratory set-ups where the current required is less than one-tenth of an ampere. Isolation is the only practical prevention of electric shock in all other applications.

CONTACT BURNS

Wherever electricity passes through an object, heat is developed. The amount of heat depends upon the current density and the electrical resistance of the object.

When a current accidentally passes through a human body, the points of contact are usually small areas. At these points of contact the current is quite dense and the amount of heat liberated in the immediate vicinity of the contact is great. Once having entered the body, the current fans out to take all available paths, thus rapidly reducing the current density. With the decrease in current density, the developed heat decreases and the ability to burn the flesh is dissipated.

Because of this fact, contact burns (burns resulting at the points of contact from the passage of current through the body) have certain definite characteristics. At the skin surface, these burns are usually of pin-point size, but they cone out beneath the skin, sometimes covering an area three-fourths of an inch in diameter in the deeper tissue. Although these burns extend along only a short part of the current path, they penetrate into muscle and tendon tissue and are quite deep by comparison to chemical or heat burns. Contact burns frequently require surgical elimination of the burned tissue and subsequent skin and tissue grafting to heal the member. Such burns can and frequently do cause partial loss of function of the injured member.

Contact burns occur in almost all shock cases; however in such cases where the victim survives, the burns are rarely severe, probably because of the small currents involved. In cases of fatal shock the severity of the contact burns is of little interest and is not commonly recorded. Severe contact burns in nonfatal cases more frequently result in those instances where both contacts with the electrical circuit are made on one limb so that current does not pass through the torso of the accident victim and therefore no severe shock occurs.

ELECTRIC ARC BURN

When an electric current is drawn through air, creating an electric arc, considerable heat is developed along the path of the arc. If such an arc occurs close to a person, the resulting heat may severely burn the proximate part of that person's body. Arc burns are therefore the result of current passing around, instead of through, the body. When an arc occurs it is usually caused by or results in the destruction of some piece of electrical equipment, with the resultant throwing about of particles of molten metal and burning oil. These particles may cause injury in addition to the arc burn itself.

ELECTRIC OPHTHALMIA

An electric arc produces, in addition to heat, an intense light. When viewed by the naked eye, this light will consume a considerable amount of the photographic, light-sensitive material of the eye that converts vision to mental impression. Continued use of the eye for normal function after viewing an arc may so deplete the supply of this material that a condition of blindness results. This condition, called ophthalmia, is almost always temporary, but it is disabling and extremely painful and may produce severe psychological effects upon a victim. In rare cases ophthalmia results in permanent blindness.

Ophthalmia can be minimized in most cases if, after viewing an electric arc, the eyes of the person are bandaged to prevent their further use. This treatment, continued for twelve to sixteen hours, will in almost every instance remove all harmful effects of the arc upon the eyes and will eliminate the painful stage of ophthalmia.

LOW-VOLTAGE SHOCKS

Most industrial electrical hazards are in the lower voltage range, 120 to 440 volts. With these voltages, and especially the lower ones, the chief shock risk is that of fibrillation. Such voltages cannot ordinarily produce asphyxiation by shock. Even to permit the flow of the small current necessary for fibrillation, it is necessary that the body contacting the low-voltage circuit be in a condition ideal for the passage of current (skin perspired or otherwise thoroughly wetted) and that the body be in intimate contact with both the ground and the live conductor. With all these conditions required, it is not surprising that most contacts with low-voltage circuits produce little or no effect upon the body and that only a very small part of the total contacts result in serious or fatal injury.

Despite all these considerations, low-voltage shock contributes a large part of all the electric shock fatalities which occur. Obviously, with all the safeguards which nature has provided for our protection against low voltage, this must indicate that a tremendous number of contacts with low-voltage circuits occur. Most of these contacts are entirely needless, and many are willful. The principal cause of such contacts is a mistaken idea that low voltage is harmless, an idea that leads to carelessness or daring in handling electrical equipment and circuits.

Some of the common causes of low-voltage electric shock in industry follow.

INDUSTRIAL LOW-VOLTAGE HAZARDS

Defectively or Improperly Designed Portable Lights. The most common defective portable light hazards are: outer shell of socket metallic, becoming live because of moisture or dirt getting inside; collar of socket too short, leaving part of bulb thread exposed; bulb unguarded, or improperly or inadequately guarded, breakage of the bulb exposing the live filament lead.

Prevention: Portable lights should be equipped with lamp sockets of hard rubber, fiber, or other non-conducting moisture-proof material. The sockets should be of sufficient depth to cover completely the socket thread, and of such shape and size as to follow closely the contour of the neck of the bulb. The light guard should be of insulating material or of insulated metal construction.

Portable Electric Tools or Machines. In any portable electric device the case may become alive because of insulation breakdown, most frequently in lead-in wires.

Prevention: A three-conductor lead-in wire may be used; the third wire, at the machine end, should be solidly connected to the shell of the equipment. At the socket end, the three wires may be brought out to a special plug which is polarized (i. e., it must be inserted in its receptacle in only one way), so that the third wire is automatically connected to an independent ground through the plug.

Alternatively the ordinary two-wire connection may be used safely if all portable electric tools are tested for insulation strength at least twice a year, in the spring and in the summer, when a low-voltage contact would be most dangerous because of sweating. Testing equipment can be built readily with a B battery and a high resistance voltmeter. With such testing, weak insulation can be detected before a breakdown is complete. All defective equipment should be immediately repaired or scrapped.

Another alternative has been tried, using a two-wire polarized system employing the circuit ground. This, however, is unsafe and in some cases positively dangerous because of unauthorized field repair of broken cords and plugs.

Improper or Defective Electric Cords Rendering Metal Objects Alive. At their origin, cords should be insulated with strong, wear-resistant covering; in service, they should be inspected frequently. In use, care should be taken to keep the cords out of contact with water or oil or sharp edges (especially sharp metal edges). They should not be allowed to become tangled or to be abused in any way. In one case, an electric cord strung over a metal door made the entire door alive and a workman striking this door with a length of pipe carried upon his shoulder was fatally shocked.

Ungrounded Cases on Fixed Machines. Every fixed machine having any electrical connection should be grounded by a suitable bond. Such bonds should be inspected frequently and tested at least annually to insure that electrolysis or vibration has not ruptured the ground connection or rendered it only partially effective. (Low-voltage equipment cases may be left ungrounded if they are so remote from any grounded object that simultaneous contact is impossible.)

Repair of Electrical Equipment or Circuits While Alive. Before any electrical equipment is repaired, the circuit should be de-energized by pulling the switch and removing the fuses. The switch should be locked in the open position in every case if possible. This protection is especially important in those cases when motor repairs are involved or when circuit repairs are remote from the switch and fuse location. Accidental closure of the circuit of a motor that is being repaired involves not only a shock hazard but also the risk of entangling the worker in the motor or in the machinery the motor drives.

In some cases it is necessary to perform repairs on live circuits; such instances are rare in ordinary industrial work, but they are common and unavoidable in public utility work. Public utility electrical workers on this type of job use rubber gloves and insulated tools and cover nearby grounds with rubber mats and bandages; they also use wooden platforms in damp locations and otherwise protect themselves from ground contacts. If such a necessity for live work exists in industry, similar precautions should be taken. In addition to the shock hazard, work on live low-voltage circuits involves the risk of flash burns and eye injury. Most ophthalmia cases result from low-voltage flashes.

Switchboard maintenance and repairs should be performed in off-hours, if possible, so that the boards can be de-energized, or at least so the circuits will be working at low loads and not as likely to produce severe flashes if broken.

Open Switchboard and Fuse Boxes. In older installations, open switchboards and fuse boxes were commonly used. These expose personnel to low-voltage shock, flash burn, and eye-injury hazards. Where such conditions exist, great care should be taken to eliminate good grounds which can be contacted while within reach of live parts, and access to the switchboard room should be limited to the required operating personnel. A wooden guard rail should be provided, placed close in front of the switchboard to prevent accidental tripping of switches by brushing against them. An insulating mat should run the entire length of the floor in front of the switchboard.

Modern installations employ dead front switches and fuse boxes, with live parts and possible sources of flashes enclosed, removing the before-mentioned hazards. In such installations, the switchboards should nevertheless be isolated to prevent tampering and other sources of improper operation.

Improper Fusing. Fuses are frequently bridged with solid metal objects so that fuse protection no longer exists on the line. Also, circuits are often overfused, that is, fused beyond their current capacity. This most commonly occurs on circuits which are chronically overloaded so that the fuses blow out with annoying regularity. Bridging of fuse links and overfusing are very common causes of fires of electrical origin.

Rheostats, Resistance Units, Controllers. These devices, by the very nature of their operation, become hot when in use and may produce heat burns on contact. They are also possible sources of shock or flash injuries. They should be completely enclosed by screening and, if possible, should be isolated as to location and should be remotely controlled.

Poorly Designed and Poorly Built Electrical Equipment. Poorly designed and poorly built electrical equipment frequently causes electrical shock and electrical fires. Only tested and approved types of equipment should be purchased and used, such as equipment labeled by the Underwriters' Laboratories.

INTERMEDIATE VOLTAGES; FALLEN WIRES

The most frequently encountered intermediate voltage is the 660-volt circuit which is primarily a traction problem. In protecting traction employees from shock, primary confidence is placed in preventing simultaneous contact with the ground and the live rail or wire. In third rail systems, this is not difficult because the wooden ties furnish an insulated walkway when dry, and very little track work is done in wet weather. In trolley systems, the location of the trolley wire is adequate protection to prevent contact.

At this voltage, a fairly large portion of contacts will result in fibrillation or non-breathing conditions. Wet lines on trolley poles have in some cases been the vehicle of shock; older type, semi-exposed circuit breakers, third-rail shoes, and exposed substation switches and switchboards are other prominent hazards.

The principal interest of industrial-accident preventionists in the 660-volt system (except, of course, those men specifically engaged in traction work) lies in the exposure of the general public to contact with these circuits. There are a number of persons killed each year by such contacts; these persons are, in general, trained workers in other industries, whose loss is a severe one to their employers. Most third-party traction electric shocks are the result of flagrant abuses of common sense on the part of the persons killed or injured. Traction groups have found no practical method of eliminating these abuses, and probably the best approach to their elimination will develop from the off-the-job accident-prevention activities of industrial safety engineers.

The practices that constitute most of these abuses are the picking up or otherwise handling of trolley wires that have been knocked down by storm or accident and the walking across railroad rights-of-way at places other than proper crossings. The former is a hazard common to traction and public-utility circuits. All persons should be informed that no wire that has fallen to the ground is safe to touch. If such a wire falls in contact with a rail or other good ground, it will " spit " and spark violently and thus warn persons away. But if, instead, it falls on earth or pavement, it will in all probability lie quietly. In this case, the wire is much more likely to be dangerous because there is little chance that a sufficient current will flow to the ground to cause the station switch to open. In fact in many cases the first notice that the station forces receive that a wire is down is the word that a person has been shocked on it. Under no circumstance should a person touch or approach a wire that is down unless he is trained and equipped to repair it. When overhead lines are down, the traction or utility company should be notified at once.

A variant of the hazard of fallen wires results from the occasional accident in which a traveling crane boom or cable touches a trolley or utility wire. If the crane is mounted on rubber tires, the entire crane becomes alive and contact with it will produce shock. If the crane body is grounded, a short circuit is created and the wire breaks at the point of contact. Contact with the fallen wires is the chief hazard under these circumstances.

Frequently contact with a fallen wire results from efforts to rescue another person who is in contact with it. It should be understood that in such accidents, not only the wire, but also the body of the person in contact with it, is charged. Touching the body invites a shock, which may readily kill the would-be rescuer. Moving the wire out of contact with the person will often cause the wire to touch a good ground, spark, and whip about, possibly touching the rescuer or others; therefore the wire should never be disturbed. A safe rescue can be performed by pushing the victim's body out of contact, using a piece of *dry* unpainted wood, or by drawing the body out of contact, using a loop of *dry* clothing or rope.

The crossing of railroad rights-of-way at improper places is a very common practice among suburbanites. The electric-shock hazard in such cases is secondary to the risk of being run down by approaching trains. In some cases, persons cross at such places because the proper crossing would take them a considerable distance out of their way. In other instances, persons regularly cross open tracks to save inconsequential extra distances. The crossing of open track is a non-industrial injury hazard which plant safety directors can well afford to study and against which they can warn their employees.

HIGH-VOLTAGE ELECTRIC CONDITIONS

In discussing low-voltage conditions, it was pointed out that a very small part of the low-voltage contacts resulted in death or serious injury. In the case of high voltages, including transmission and distribution voltages, almost every contact results in serious or fatal injury. In the range from 1,000 to 7,500 volts, almost every contact which causes current to flow across the body will cause a non-breathing shock condition. Of these, about half can be revived if artificial respiration is promptly commenced; very few will recommence breathing without this first aid. Circuits of more than 7,500 volts need not be contacted to produce severe injury since the ability of electric current to jump a gap becomes prominent in this range. Involvement with circuits of such high voltage is almost invariably fatal, although the effects of shock in such cases are often counteracted by the pain of the extensive burns, so that high-voltage victims often die of burns rather than of shock.

Most high-voltage conditions in industrial plants are found in the vaults containing the power feeds. In the design of these vaults, provision is usually made for completely isolating the equipment from casual contact by placing the vault in an out-of-the-way part of the building and by providing means of locking the vault to prevent unauthorized persons from entering it.

Abuses of the vault isolation have been so frequent that utilities have been forced to provide double-ended lock hasps, one end holding their lock and the other being closed by a lock provided by the plant. In this way, it is always possible to determine which party is responsible for the vault being open.

Public utilities maintain periodic inspection of the vaults which they supply. In the course of such inspections, it is not uncommon to find vault doors blocked open and the vaults used for storage space or for other improper purposes. In some instances, it has been found that steam, water, or sewage lines have been run through the vault doorway so that the door could not be shut. Such conditions exist in spite of municipal requirements that vaults be of fire-resistant construction and be provided with automatic door-closing devices. Needless to say, these conditions are open invitations to electric-shock injuries and to fires as well, and they should not be tolerated by plant management.

The principal causes of industrial high-voltage accidents are access to the vault equipment by persons unfamiliar with the equipment, and attempted repair of high-voltage equipment by plant-maintenance men.

In any plant, the high-voltage hazard can be completely controlled by a rigidly enforced executive policy requiring that the vault be kept locked at all times and that plant personnel should never attempt to repair high-voltage equipment. All such repairs should be made by specially trained persons, preferably the maintenance crews employed by the manufacturers of high-voltage equipment.

Fortunately most persons have a well-developed respect for electricity in the higher-voltage range, so that it is not difficult to convince them of the advisability of avoiding contact. When accidents do occur from high voltage, it is frequently determined that the injured person was wrongfully instructed to perform a hazardous task and did so in fear of losing a job, or that the contact resulted from the thought that the equipment was dead, when in fact it was alive.

To insure accurate instructions, public utilities, whose employees work on high-voltage equipment, have devised a simple safeguard. If a man is instructed to work upon a line or equipment which he believes to be alive, he may without prejudice ask the person who so instructs him to touch the part first. This ruling naturally induces a high degree of caution with regard to the giving of instructions. This is supplemented by detailed, positive means of identifying equipment and by procedures that require that high-voltage equipment and lines must not only be de-energized, but must be subsequently short-circuited and connected to ground before any work can be done upon them.

HIGH-VOLTAGE HAZARDS IN ELECTRIC UTILITIES

In electric-utility work it is necessary that electrical energy be generated, transmitted, and distributed at high voltages. Most of the hazards incident to these functions can be eliminated by proper equipment, protective devices, and work procedures. In many cases it has been necessary to make fundamental changes in the basic design of the electric system in order that particular hazards might be removed; over the course of years many means of so changing the systems have been developed. Ten years ago, it was common practice to work on live, underground lines carrying 2,400 volts. In the intervening years, alternative means of feeding each area have been installed so that now, in most companies, no underground line over 120 volts is opened when alive. In addition to opening the switches that kill the circuits, it is common practice to put intentional short circuits and grounds on them in the station, and to spear the cable in the field before its sheathing is removed. Cables are speared by driving a metal spike through the cable sheath and insulation to the conductors; in this operation, an insulated pneumatic device, that permits the employee to stand at a safe distance from the cable, is employed.

Modern equipment and modern methods of working on electric circuits have eliminated most of the hazards formerly associated with the generation and distribution of electricity. In many places it has been impossible to institute the newer and safer methods because they do not fit the old equipment. Therefore, many of the old hazards still exist and should be described.

STATION HAZARDS

In older installations oil-circuit breakers occasionally exploded. Such explosions occurred in most cases because of short-circuit currents in excess of the ability of the breaker to interrupt. This condition existed, at one time or another, in every system which participated in the rapid expansion of the electrical industry in the early 1920's. It developed because of the huge increases in the generator capacity, which increased the possible short-circuit currents to many times the capacity of the existing breakers. It has been effectively controlled in most cases by the segregation of circuits, limiting the number of generating units which could feed into a short, and thereby limiting the short-circuit current to values within the breaker capacity. Current limiting reactors, where they can be installed within the area limits of the station, are an even better device.

On old equipment, short-and-ground connections were usually made outside the body of the switch or bus structure. Serious accidents occurred because of wrong identification (resulting in shorting of live equipment) and because of workers neglecting to remove the shorts on completion of the work. Such hazards have been removed by the double-checking of cable or equipment identification, requiring the station operator to report to a superior by telephone the equipment he has been ordered to open, and also requiring him to see that the workmen work only on the equipment he has killed. Short-circuit and ground connections should be long pieces of cable rather than short straps to minimize the chance of workmen leaving them in place. On modern equipment the short-and-ground connection is put on by switch operation, and the grounding switch is so connected that it cannot be closed until the line switch is open.

Painting, cleaning, and other minor maintenance operations in the vicinity of live electric equipment are the most common causes of electric shock from high voltage among men not directly employed on electrical work. Such work should be done by, or supervised directly by, men familiar with the equipment and with the hazards of electric operations. Even with such supervision, no maintenance operations of this sort should be done above live equipment or within reach of the live leads.

Preventive-maintenance schedules should always be set up and followed on high-voltage station equipment since minor defects, such as dirty oil, can cause equipment failures through explosion or fire.

HAZARDS ON OVERHEAD LINES

In work on overhead lines, there is a constant hazard of electric shock. Even if the line on which work is being done is dead, neighboring lines are likely to be alive, and contact with them will produce shock. This hazard is inherent in the overhead system and cannot be completely eradicated.

The handling of lines in erecting, shifting, or removing circuits is one of the common causes of fatal accidents. This work is usually done on dead lines in close proximity to live lines. Because this is a strenuous task, the chance of brushing against the adjacent live lines is comparatively great. Line hose should be used freely in doing this job, but, because the amount of time spent on any one pole is small, and because the linemen must move from pole to pole, there is a tendency to skimp on its use. This single source accounts for a considerable number of fatal accidents.

The handling of lines is also responsible for another type of accident. Frequently, in moving the new line to its proper place or in pulling down an old line, the line upon which the work is being done contacts a live line and becomes charged. If men are working on the new line at another spot, making it alive in this fashion may readily cause them to be shocked. Prevention of this type of accident requires simply that either no work be done on a section of line until the entire section is in place, or that men doing work before completion of the section be protected as though the line were alive.

When a man walks or climbs past energized equipment, he should take the same precautions that would be required if he were to work near them. Frequently workmen feel that, if they are to be close to the point of danger for only a short time, no special care need be taken to prevent injury. Casual contacts with charged equipment while passing it are the cause of many fatal injuries. (This hazard is common to overhead lines and station work.)

Splicing or separating live lines results in comparatively few injuries, considering the potential hazards of these operations and the frequency of exposures. Nevertheless, these operations are outstanding causes of fatal shocks, in most cases resulting from one of the following conditions: contact with an unprotected wire other than the one being spliced, the tie wire hitting the arm above the rubber gloves, unprotected rubber gloves punctured in the course of the work, and non-use or inadequate use of rubber hose and blankets. These general precautions should be followed in work on overhead lines.

1. Cover all grounds within reach with rubber blankets, mats, or line hose fastened in place. The cases of transformers are grounded and should be covered. Secondary wires are, for practical purposes, grounds and should be covered if within reach.
2. Cover every live line within reach with a line hose. If possible, work below live lines.
3. If working on live lines of less than 4,000 volts, wear rubber

gloves with protectors. If working in congested space, wear rubber sleeves in addition to the rubber gloves.

4. Never permit a live-line connection to dangle loosely. Snub it in a safe place with rope until ready to connect it.

5. Rubber gloves should be initially tested, upon purchase, at three times the voltage on which they are to be used. They should be retested at least monthly and air-tested (tested for air leaks) before each use. Leather protectors in good condition should be worn over the gloves at all times.

6. Rubber gloves are not to be used on lines above 4,000 volts. For live work above this voltage, hot-line tools should be used. These consist of tools mounted on long handles that are made of insulating material. The tools are so designed that most manual tasks can be done with them at a safe distance from the hot line. (In no case should dependence be placed upon two pairs of rubber gloves, worn one over the other.)

ELECTRIC WELDING

While this subject is not related directly to the general subject of industrial electrical hazards, this is the most appropriate place at which to insert a general outline of electric-welding hazards. These are: eye injuries from the light of the arc, skin burns by radiation from the arc, burns from contact with hot metal, burns from drops of molten metal or from fires started by these drops, and metal-fume fever resulting from inadequate ventilation.

Welding lenses are available to prevent eye injury. These come in a number of shades, dependent upon the intensity of the light. Federal specifications for welding goggles are as follows.

No. 5. Light gas cutting; light electric spot welding.
No. 6. Gas cutting; medium gas welding; arc welding with currents less than 30 amperes.
No. 8. Heavy gas welding; arc cutting and welding with currents from 30 to 75 amperes.
No. 10. Arc cutting and welding with currents from 75 to 200 amperes.
No. 12. Arc cutting and welding with currents from 200 to 400 amperes.
No. 14. Arc cutting and welding with currents over 400 amperes.

Not only the welder and his helper but also the foreman, inspector, or other observers should be protected. On light welding and cutting operations, goggles furnish adequate protection. On heavy work, the welders and their helpers should wear welding hoods or helmets; for the other exposed persons, goggle protection is usually adequate.

Skin burns from welding are comparable to severe sunburn. They can be effectively controlled by the use of hoods, arm guards, leather jackets, and gauntlet gloves. These also prevent burns caused by contact with work or tools, and burns from drops of molten metal. In close work, leather leggings are required for the protection of legs and ankles.

Fires started by metal drops cannot be seen through welders' goggles. Consequently, they may gain considerable headway before being noticed. All flammable materials should be removed if possible from the vicinity of the welding operations; in addition an adequate fire watch should be established.

In cutting metal work painted with lead paints, the hazard of lead poisoning from the fumes is severe. Similarly, cadmium plate (or cadmium-bearing paint) gives off cadmium oxide, which is toxic. Poisoning from one of these sources is likely to prove serious, with a rather large chance of permanent disability.

In work on galvanized sheet metal and in brazing there is a hazard of a far less serious metal-fume poisoning that may cause temporary disability but is not likely to result seriously. These hazards can be effectively controlled by general ventilation, by local exhaust at the site of welding, or by the wearing of proper air-supplied respirators. General-ventilation control systems should be capable of the following rates of removal.

Steel Electrodes	*Exhaust Capacity, cubic feet per minute per welder*
5/32 inch	250
3/16 "	400
1/4 "	700
5/16 "	1,200
3/8 "	1,500
Alloy Electrode (fluoride coated)	
5/32 inch or less	250
Galvanized Plate	
5/32 inch	1,000–1,500

Local exhausts, to be effective, must be within 9 inches of the welding operation. The air flow at the hood of such a device should be at least 200 cubic feet per minute.

(Note: for a fuller discussion of welding operations and the associated hazards see *Special Bulletin 5, U. S. Depart. of Labor.*)

CHAPTER XIV

Investigation of Accidents

From the viewpoint of accident prevention, the most important event occurring after an accident is the accident investigation, which seeks to prevent recurrence by the detection and elimination of the preventable causes and sources of the accident.

Although this is the most important procedure, the most pressing need immediately after an accident is to assure that the injured person is properly treated so that the injury is not aggravated. To put the investigation and treatment in their respective places, it is necessary that a definite procedure in case of an accident should be established and enforced. The procedure should establish both the things to be done and the order in which they are to be done. This is especially important in serious injuries, in which the following order should be maintained. 1. Give proper first aid to the injured. 2. Avoid moving the injured person unless it is necessary to remove him from serious impending danger. 3. Arrange for medical aid to be dispatched to the scene of the accident. 4. Notify the safety director. 5. Commence the foreman's investigation of the accident.

In minor injuries, where the injured employee can proceed to the treatment center, the employee should be given first aid; a short statement should be taken for the accident report; the employee should be sent to the treatment center; and the foreman should proceed with his investigation. The dispatching of the injured should not be unduly delayed in order to take the statement. If necessary this can be completed later.

This subject is more completely discussed in the chapter, " First-Aid Facilities." It is mentioned here to place the accident investigation definitely in its proper order in the after-accident sequence.

Scope of Investigation. The accident investigation should cover the necessary identification of the injured person, the names of the witnesses, and personal statistics. In addition, the investigator should attempt to discover the entire accident sequence, the human fault, and the physical hazard. Naturally, greater progress can be made in accident prevention by detecting and correcting physical hazards. Through this means the accident cause can be completely removed. In the case of the human fault, however, the cause can be minimized and reduced by training and education but can never be completely eliminated.

When several physical hazards contribute to an accident occurrence, the elimination of one of the physical hazards is not sufficient. In most cases it will be necessary to eliminate all of them or else to devise methods for their control. When the investigator has determined the hazard or hazards, the next step is to explore the possibility of their elimination. This requires assembling all the facts pertaining to the accident and to the process involved, and developing positive recommendations for eliminating the hazards.

Blame Fixing. Blame fixing is often resorted to as a simple expedient to eliminate the necessity of a thorough investigation. Almost always some rather prominent human fault is the apparent basic cause of the accident. Focusing attention on the human fault obscures the real purpose, which is the elimination of the physical hazard. Therefore the investigator should resist any attempt at blame fixing. (Frequently a policy of blame fixing causes non-reporting of accidents with resulting infections of minor injuries.)

Disciplinary Action. Disciplinary action usually means punishment, often in the form of time off without pay for a short period. Punishment is a natural step subsequent to blame fixing and is equally ineffective as far as accident-prevention progress is concerned. When punishment follows an accidental injury and no punishment is provided for a non-injury accident, attention is directed to the injury (and not to the accident) as the more important feature. Discipline also pyramids misfortune on the injured person and is likely to antagonize the other workers by an appeal to sympathy for the underdog. Punishment leads to buck passing, with each man guarding his own interest, and obscures the real facts of the accident. The effort is almost always made to blame the injured person if he is not present or is otherwise unable to defend himself. The injured man, because of his painful experience, is not likely to perform the same act again at the risk of repeating the injury. Therefore, discipline is not a necessary or valuable part of his training.

Following are several types of accidents in which discipline is proper, necessary, or advisable. An employee, through horseplay, temper, willful disobedience of an order, or failure to perform his proper function, causes injury to another. An injury follows willful violation of a proper rule. Stress should be placed upon the propriety of the rule, and investigation may be necessary to determine whether the specific rule is a cover-up or whether the rules are too numerous or complex. An employee willfully avoids using the prescribed personal-protection equipment provided.

Foreman's Investigations of Accidents. In most plants each accident is investigated by the foreman to whom the injured person was responsible at the time it occurred. On the basis of this investigation, the foreman prepares a report which is presented at the regular meeting of the foremen's safety committee or some other group meeting of the foremen. Here the accident is discussed, and the cause of the accident is determined. According to the cause of the accident, a classification code is applied. The foreman is required to furnish enough facts so that a clear picture of the accident sequence is presented to the committee. If he has not done so, the matter is tabled and the foreman must re-open his investigation to learn the required additional information. In this way the foreman receives valuable training in accident investigation and becomes conscious of accident causes and their prevention. In cases where the foreman disagrees with other committee members on the accident classification, the matter should be referred to the executive or to the central safety committee for decision.

The safety director should keep in close touch with the accident-coding activities of the foremen's committee to assure that the classification coding is not being abused or used as a cover-up for supervisory failures. The fact that the safety department or any other agency has investigated an accident should in no way free the foreman from his responsibility for conducting his own investigation and preparing his report.

Safety Department Investigations of Accidents. It would be desirable to have every accident or near accident investigated thoroughly by a trained safety inspector in order to have all possible facts available for guiding the accident-prevention activities. However, in most cases this is impractical. For example, for a plant having 100 employees, an average annual accident experience would be 4 lost-time accidents, 120 minor accidents, and 1,200 no-injury accidents. It would require the full-time work of a trained investigator to investigate all of these. Since no company would permit one investigator for every hundred employees, it is impossible to investigate all accidents. In order to arrive at a practical compromise, it must be remembered that some accidents are unpreventable and that many are impractical to prevent. Obviously it is unnecessary to investigate thoroughly the unpreventable or the impractical-to-prevent accidents. It is therefore usual for the safety department to investigate all lost-time accidents, investigate all accidents in which there is a danger of serious injury or where serious injury may have been imminent, investigate all minor accidents that are frequently repeated, and investigate such near accidents as are brought to the attention of the safety department.

It should be pointed out here that, if the foreman investigates all of the near accidents, only those that are considered important will be brought to the attention of the safety director.

Committee Investigations of Accidents. In many small plants where the safety function is a part-time job performed by an executive or a staff assistant, a committee is set up to investigate serious and potentially serious accidents. Frequently such committees function effectively; where this occurs, it will be found that the chief executive shows a real and live interest in the committee work and probably participates actively in the investigation.

Accident-investigation committees are ineffective in most cases because of the common organizational weakness of all committees, the difficulty in obtaining united opinion and concerted action, and the absence of members because of other business which is considered more important. As a result, the committee activity dwindles until only those accidents that cause extreme injury or death are investigated.

Insurance Company Investigations of Accidents. The carriers of compensation insurance usually investigate all serious-injury cases, although some carriers undertake investigations of all reportable injuries. Investigations by insurance companies cannot, therefore, be considered as replacing safety-department or committee investigations, but rather as supplementing them. Because of their broad experience and knowledge, the insurance carriers are able to bring into an accident investigation much information unknown to plant personnel, especially with regard to effective measures for the prevention of recurrence.

Relationship of Various Types of Accident Investigation. The reports of accidents prepared by the foremen are the foundation of the accident-investigation program. These reports cover all accidents and are necessarily brief. On the basis of the foremen's reports, the safety department or investigating committee selects for further study those accidents that produced or could have produced serious injury, and those frequently recurring minor-injury types that offer an opportunity for effective prevention.

The insurance-company investigations of serious-injury accidents are chiefly advisory in their nature and bring into the study of those hazards that have proven serious, the advantage of broader experience. Of these types of investigations, the one that is most important to the accident-prevention program is the safety-department investigation. The remainder of this chapter is devoted to the selection and training of men for this work.

Requirements for Safety-Department Investigator. The investigator must be reasonably well informed as to the nature of the work, the work processes, the various tools available and their proper use, and the methods used in doing the work. He must have the confidence of the foreman and other key supervisors. He must be reasonably intelligent and able to distinguish between *facts* and *opinions.* He must be sensitive to blame fixing and prevent witnesses from incorporating such ideas in their statements. He must be able to unearth essential facts and to judge when he has enough for a complete and coherent story. It is desirable that he be a competent first aider, capable of administering aid or supervising others who may be required to give aid. He must be able to determine preventable causes quickly and intelligently. The investigator should be able to express himself clearly in writing and to speak at small gatherings. He must not be overawed by persons of higher rank, nor be contemptuous of their rank.

Selection of Men for Investigator Training. Investigators are frequently developed from within the plant organization. From the above requirements it is apparent that the investigator must be of a supervisory type. Under normal conditions it is desirable to select a young man for the job.

Such qualified men are often found among the sub-foremen of the maintenance crew. They make excellent investigators because of their wide knowledge of equipment and processes. Also the sub-foremen of the production force often make excellent investigators.

Training Investigators. All persons assigned to investigation should be given thorough and specific training in the ground work of safety engineering, fire prevention and protection, and first-aid technique. While in training, they should be permitted to attend meetings of the safety committee and to accompany a trained investigator on the regular investigating work. They should be assigned, for this training, to competent investigators who are willing to pass along information in order that the trainees may learn quickly. They should also be required to make periodic general inspections and to investigate the progress of pending recommendations in order to familiarize themselves with the equipment and the detection of accident hazards. As soon as the investigator shows ability, he should be given responsibility commensurate with his progress.

During the training period the work of the investigator should be watched rather closely. Any tendency to fix blame should be immediately checked and discouraged. He should be trained to find all of the causes and required to make a thorough explanation of the accident background. He should always be required to furnish recommendations for correction.

The investigator should be protected from persons who attempt to use his position for selfish purposes. He will soon learn to protect himself after he has gained some experience. Neither his report nor the material disclosed by him in confidence should be misused. Failure in this will result either in his loss of confidence in his work or in the employees' loss of confidence in the investigator.

Rejected recommendations should be discussed with the investigator in order to determine if a substitute recommendation is desirable or if the recommendation should be rewritten. Where neither alternative is found desirable and it is agreed that the recommendation should be rejected, all of the pertinent facts should be brought to the attention of the investigator who made the original recommendation. There is a close relationship between accident investigation and safety inspection, and they are most often performed by the same persons.

CHAPTER XV

Fire Prevention and Extinguishment

No attempt will be made to cover all of the related items of fire prevention because of the broad scope of this subject. Only the more important industrial hazards will be discussed.

Losses Resulting from Fires. Fires are responsible for the loss of eight thousand lives annually in the United States alone. There are also many people who suffer serious injuries as the result of contact with fire, and others who incur numerous ills and respiratory ailments directly or indirectly attributable to breathing products of combustion or noxious vapors generated from the use of first-aid fire-fighting equipment in confined spaces.

The loss, by fire, of material, buildings, plants, and structures in one year in the United States approaches 300 million dollars. This is of even greater importance at the present time than the injury loss because of inability to replace many of the vital articles and materials destroyed.

Injuries Resulting from Improper Use of Fire-Extinguishing Equipment. Many injuries are sustained as the result of failure of the equipment itself, such as the explosion of a soda acid or a foam extinguisher. Many burns are sustained in fighting fires by inadequate knowledge of the proper use of the extinguisher.

Carbon tetrachloride decomposes on exposure to intense heat, liberating phosgene gas; in the presence of moisture, phosgene decomposes to form hydrochloric acid. If phosgene is inhaled, hydrochloric acid is formed in the upper respiratory tract, and a severe irritation results which may cause serious injury or death. Carbon tetrachloride extinguishers, therefore, should not be used on fires in confined spaces except with gas-mask protection.

These injury sources can be effectively controlled by: (1) careful placement of fire extinguishers, and provision of required personal protective equipment; (2) monthly inspection of fire extinguishers; and (3) yearly training of key personnel of the plant in the use of all fire extinguishers employed.

Prevention and Control of Fires Incorporated in Design. In the initial design of a plant, the fire hazards associated with the product to be manufactured should be considered and proper safety features included. Fireproof construction is naturally preferred. Where such materials are not available, the materials used should be so treated that they resist or retard fires. Adequate fire exits should be provided and facilities made available for increased plant capacity and increased personnel so that adequate space for exit accommodations can be installed when such expansion has been effected.

The fire-extinguishing equipment to be provided in the plant must be selected to combat the particular hazards involved. Here again the nature of the product, the kind of materials, and the manufacturing processes must all be carefully considered before such equipment is purchased and located. The size of the equipment must also be determined from the nature of the hazard. The details of the various types of extinguishing equipment will be given later.

Fire Hazards in Construction. During the construction period of the plant many unusual hazards are encountered. These are caused by welding operations in the presence of wood scaffolding and other combustible equipment temporarily used during the construction period. The problem of housekeeping among contractors and construction men is always difficult, and the presence of refuse and combustible materials during construction often introduces numerous hazards.

Some Common Fire Hazards in Plant Operation. Many fire hazards can be detected by the regular and conscientious use of a self-inspection form. There are many types of these forms in use for various industries, and they can be obtained from the National Board of Fire Underwriters, 85 John Street, New York 7, N. Y.

There are many causes of fires. The most common perhaps are smoking and the use of matches. Poor housekeeping, in addition to being an accident hazard, is a very serious fire hazard. Various kinds of heating apparatus, heating appliances, salamanders, and such equipment are often the direct cause of fire.

Improper use of electricity, inadequate equipment for conducting and handling electricity, the use of oils, paints, and other flammable liquids, or power transmission and generating equipment with excessive heating or hot bearings may be the primary cause of fire. Static electricity in atmospheres containing flammable vapors or gases is also a common cause.

Watchmen, Fire Prevention, and Control. The selection and training of persons assigned to watchmen's duties is more important than is generally realized. Men assigned to this work should be instructed to shut off the section of a sprinkler where water damage may become excessive either from the sprinkler opening because of the heat or the failure of sprinkler piping. Where the plant might be shut down over long weekends, the watchmen should be capable of replacing a sprinkler head and restoring the water supply. These men should be given special training in the use of first-aid fire-fighting equipment and, in general, should have some appreciation of the degree of responsibility assigned to them. Where automatic thermostatic alarms are provided, the watchmen should be familiar with the system and should know the locations from which the signals originate.

Housekeeping. Combustible material, oily rags, or other scrap that can ignite through spontaneous ignition, or any other cause, should be properly removed and, while in storage, should be kept in safe containers. This is a responsibility of management and should be stressed through the supervisory group.

Changes in Plant Equipment and Personnel. Changes in the production process and changes in the plant personnel should be reported to the authorities responsible for fire-prevention activities in order that the necessary revisions may be made in the allocation of fire-fighting equipment. These changes may also result in the training of employees reassigned as watchmen or to some other form of work that requires a knowledge of fire prevention and extinguishment.

Maintenance of Fire-Extinguishing Equipment. The maintenance of first-aid fire-extinguishing equipment includes discharging, cleaning, repairing, refilling, and painting. There are two general plans for maintaining this equipment, each of which has certain advantages and disadvantages. They may be generally defined as the centralized plan and the decentralized plan.

In the centralized plan the responsibility for maintenance is clean cut irrespective of the location of equipment. It is allocated to a group of specialists, and it is their direct responsibility to maintain all first-aid fire-fighting equipment. They are required to have knowledge of the equipment and to maintain a schedule of inspection, recharging, and repair that can be rigidly followed.

The centralized plan permits the use of minimum stock of extinguishing agents and materials. The men employed in the work become especially skilled in the types of equipment and the general maintenance problems. They are particularly qualified to handle hazardous substances, such as acid and carbon tetrachloride, used in connection with this equipment.

In the decentralized plan the responsibility is delegated to the operating group that is in the same locality as the equipment. If this plan is used, at least one person in each location should be experienced in the operation of the extinguishers. A major defect in this system is that other operations or other maintenance may upset the schedule of maintaining fire-fighting equipment since it is not a primary job, but rather a secondary job. Each operating group will require some stock of material for recharging, which will increase the total amount of material required. Protection against the exposure to hazardous material may not be adequate because of the inadequate facilities or untrained personnel.

Fire Training of Plant Personnel. All employees in industrial establishments should have some knowledge of fire prevention and extinguishing and should know how and where to report a fire. The supervisory employees and foremen should be given specific instruction in the actual use of first-aid fire-fighting equipment. Some companies use the extinguishers that are scheduled for recharging to instruct selected men in the use of the extinguisher under actual fire conditions.

Special fire brigades have been organized in many of the large industrial plants. Specific information concerning the procedure to be followed in establishing such brigades may be obtained from the National Fire Protection Association.

All employees who are given training in the use of first-aid fire-fighting equipment should at the same time (or at some other convenient time) be given instruction in the use of gas masks or other respiratory protective devices that may be provided on the company premises, in order that they may be utilized if required when the fire-fighting equipment is used. Many employees are never "sold" on the use of a gas mask until they have actually been required to wear it in a gas chamber or a smoke-filled compartment.

The type of training to be given should be planned to suit the needs of the particular industry. The nature of the hazards should be considered before the training program is adopted. In any case, the training should include the actual handling of an extinguisher in extinguishing a real fire similar to the type likely to be encountered in the plant.

The soda-and-acid extinguisher, the fire pail and tank, the sprinkler system, and the hand pump all utilize water as the extinguishing agent. Water extinguishes through cooling, quenching, and blanketing. Water is best suited for Class A fires, which are of wood, textiles, and rubbish.

The foam extinguisher uses the loaded stream or the dry powder, chemicals designed to mix with water in most cases, in such a manner as to form a foam blanket over the surface of oil or other burning material and thus to extinguish the fire by shutting off the air supply. It is therefore used primarily on Class B fires which are of oil, greases, and paints.

The carbon tetrachloride extinguisher operates by means of blanketing. The vaporized liquid rapidly cuts off the supply of air. It is ideal for use on live electrical equipment and is best suited for Class C fires, which are in electrical equipment, although it may be used on other types of fires. It is not particularly adapted to Class A fires.

Carbon dioxide is an inert gas that is heavier than air and extinguishes by blanketing. It also has some cooling effect because the liquid, when liberated, produces carbon dioxide gas at an extremely low temperature. It is ideal for Class C fires on live electrical equipment because the equipment is not damaged by the use of the extinguisher; the damage is limited to that caused by the fire. This extinguisher is also effective on Class B fires because of the blanketing of the gas and exclusion of air. It is of practically no value on Class A fires.

Dry powders, such as bicarbonate of soda, extinguish fire by blanketing and sweeping and are best suited to Class B fires because they cut off the oxygen supply. They may be used on Class C fires because they are non-conductors. They are of practically no value on Class A fires, the chief difficulty being in the application of the powder to the fire.

There are other types of extinguishing media utilizing fine-water sprays and steam. These are suitable for Class B fires in tanks and other enclosed places where the volume is not too great and where the oxygen content may be lowered by introduction of the water vapor. Fog systems may be used safely and effectively on live electrical equipment.

Automatic Sprinkler Systems. The most important of all fire-extinguishing apparatus is the automatic sprinkler. This is a device that operates when a predetermined temperature is reached. The range of available temperature settings is from 135 to 500 degrees Fahrenheit. Various types of sprinkler heads may be purchased for any particular operating temperature. The operating temperature is indicated by the coloring of the fusible part of the sprinkler head. A sprinkler system may be described as a complete piping system throughout the building, with sprinkler heads located from 8 to 12 feet apart. The usual system is connected through a large-size standpipe to a roof tank and is also connected to the street for pumping engines to carry on after the roof tank has been emptied. A check valve in the line prevents pumped water from going back into the tank. Usually a small-size line with a float valve maintains the water level in the tank. The piping system progressively reduces in size as the groups of sprinkler heads are tapped off. Normally the entire system is completely filled with water. There is one objection to this, however, in parts of the building where freezing may occur. In such locations a dry system is used which utilizes air pressure in place of water. When a sprinkler head releases, the air pressure falls; the water then flows in, filling the pipe and flowing out through the released sprinkler head. There is some time lag in this operation, but it is not sufficiently serious to impair the use of the equipment.

Shut-off valves are occasionally provided for large sections of the building in order that the watchman or other attendant may shut off that section when the fire is extinguished and replace the sprinkler head. This prevents excessive water damage and restores the system to normal operation quickly.

Most sprinkler systems are equipped with an alarm device that is actuated by the flow of water through the sprinkler piping. Water used in sprinkler systems should be relatively pure; excessive salt or other chemicals in the water may cause serious corrosion. This action is more rapid than in water-supply piping because the water remains stationary most of the time.

Sprinkler systems should be well maintained. Special care must be taken that painters do not apply paint to the sprinkler heads since painting raises the temperature at which they operate or may render them completely inoperative. Complete information regarding sprinklers should be obtained from the local inspection bureau or from the National Fire Protection Association.

Supervision of Fire Prevention. Facilities for prevention and extinguishing of fires, together with a fire-training program, are more important than is generally realized. The chief executive must use considerable care in allocating this responsibility in the organization. In most cases it is assigned to the safety director and his staff because of the unusual degree of hazard to life and property. The importance of the proper use of gas masks and other respiratory equipment in connection with fires is another reason for selecting the safety director and his staff for the supervisory work. The problems of inspections, maintaining interest, responsibility for follow up, relocating and changing of equipment, retraining of employees, importance of proper maintenance of equipment, possibilities of changes in the hazards themselves, and changes in personnel make it desirable for a competent person to be in charge of this function. In many respects it is similar to the accident-prevention responsibility of the safety director. Therefore he is the logical person to be assigned this task. It differs somewhat from the usual work assigned to the safety director since it is not a staff function but more of a line function. It does, however, involve some staff responsibility in that he must obtain the complete cooperation of all the department heads in order that their men may be trained to assist him in the proper maintenance and use of all extinguishing equipment located throughout the plant. Where it is considered desirable to allocate the greater part of this function to a separate unit, such as a plant fire department, or a similar organization, there should be very close cooperation between this unit and the safety director.

The employees of the municipal fire department are, in most cases, not adequately trained to fight fires on high-tension and live electrical equipment. They frequently expose themselves to electric shock through lack of knowledge of the equipment and hazards involved. The regular employees in charge of such equipment should be provided with adequate first-aid fire-fighting equipment that may be used with safety on live equipment, and every effort should be made to prevent members of the local fire department from exposing themselves to electrical hazard or from increasing the damage to equipment through the use of

CHARACTERISTICS OF COMMON

Type			Pails; Pails in Tanks	Soda and Acid	Foam	Vaporizing Liquid
Chemicals or liquids employed			Water or calcium chloride solution.	Bicarbonate of soda solution and sulphuric acid.	Solutions of aluminum sulphate and bicarbonate of soda with foaming agent.	Specially prepared carbon tetrachloride with important components for lowering freezing point.
Method of operating			Throw contents	Invert	Invert	Pump or open valve
Method by which pressure is created				Chemical reaction	Chemical reaction	Pumping action or pressure
Effective range of stream			5 to 10 feet	30 to 40 fect	30 to 40 feet	10 to 20 feet
Rated liquid capacity of common sizes			10, 12, and 14 quarts	2½, 1½, and 1¼ gals.	2½ and 1¼ gals.	1 to 2 quarts 1 to 3½ gals.
Nature of principal extinguishing agent			Liquid	Water solution	Foam, mass of bubbles filled with carbon dioxide gas.	Heavy gas produced when liquid is vaporized by fire.
Principal extinguishing effect			Cooling and quenching	Cooling and quenching	Blanketing	Blanketing
Is it recognized as adapted for use on	Class A Fires	Wood, Textiles, Rubbish, Etc.	Yes. Fires in such materials can generally be extinguished by cooling or quenching effect of water.	Yes. Fires in such material can generally be extinguished by cooling or quenching effect of water solutions.	Yes. Blanketing action generally effective in such fires. Cooling and quenching effect also present.	No. But has some value on small fires.
	Class B Fires	Oils, Greases, Paints, Etc.	No	No. Blanketing effect not available.	Yes. Blanketing effect of foam produced effectively excludes oxygen from fire.	Yes. Blanketing effect of gas formed when liquid strikes fire excludes oxygen.
	Class C Fires	Electrical Equipment or Apparatus	No. Extinguishing agent conducts electricity.	No. Extinguishing agent conducts electricity.	No. Extinguishing agent conducts electricity.	Yes. Liquid is practically a non-conductor of electricity.
Should it be protected from freezing?			Yes. Unless calcium chloride solution is used.	Yes	Yes	No
Underwriters' classification. Letters indicate class of fire as above; figures indicate number of devices per unit of protection.			Water pails: A-5. Water pails in tank: A-1.	2½ gal. A-1 1½ gal. A-2 1¼ gal. A-2	2½ gal., A-1; B-1 1¼ gal., A-2; B-2	1 to 2 qts., B-2; C-2. 1 to 3½ gal., B-2; C-1

Calcium chloride solutions for water pails and
hand pump extinguishers
2½ Gallons Anti-Freezing Solution

Freezing temperature		Calcium Chloride	Specific Gravity	Degrees Baumé
10° F.	2 gals. 1 qt.	5 lbs.	1.139	17.7
Zero F.	2 gals. 1 qt.	6¼ lbs.	1.175	21.6
10° below zero F.	2 gals.	7 lbs. 6 oz.	1.205	24.7
20° below zero F.	2 gals.	8 lbs. 6 oz.	1.228	26.9
30° below zero F.	2 gals.	9 lbs. 2 oz.	1.246	28.6
40° below zero F.	2 gals.	10 lbs.	1.263	30.2

HAND FIRE EXTINGUISHERS*

Hand Pump	Anti-Freeze†	Carbon Dioxide	Loaded Stream	Dry Powder
Water. For freezing temperatures use special grade calcium chloride free from corrosive elements.	Special charges	Carbon dioxide	Special alkaline solution	Bicarbonate of soda and other powders.
Pump	Invert or invert and bump	Open valve	Invert and bump	Open valve
Pumping action	Chemical action or cartridge	Stored in cylinder under pressure	CO_2 cartridge	CO_2 cartridge
20 to 30 feet	30 to 40 feet	5 feet	30 to 40 feet	5 to 8 feet
2½ and 5 gals.	2½ gals.	2 to 20 lbs.	1, 1¾ and 2½ gals.	12 to 25 lbs.
Water, or calcium chloride solution in water.	Liquid, calcium chloride solution	CO_2 gas and snow	Alkaline solution	Dry compound
Cooling and quenching	Cooling and quenching	Blanketing	Cooling and quenching	Blanketing and sweeping
Yes. Fires in such material can generally be extinguished by cooling or quenching effect of water solutions.	Yes. Fires in such material can generally be extinguished by cooling or quenching effect of water solutions.	No. But has some value on small fires.	Yes. Cooling and quenching action.	No. Other types better adapted.
No. Blanketing effect not available.	No.† Blanketing effect not generally produced.	Yes. Blanketing effect of gas excludes oxygen.	Yes. No blanketing but has some good effect.	Yes. Cuts oxygen supply from fire.
No. Extinguishing agent conducts electricity.	No. Extinguishing agent conducts electricity.	Yes. Practically a non-conductor of electricity.	No. Extinguishing agent conducts electricity.	Yes. Non-conductor.
Yes. Unless calcium chloride solution is used.	No	No	No	No
5 gal. A-1 2½ gal. A-2	A-1†	B-4‡ B-2; C-2 B-2; C-1 B-1; C-1	A-1, B-2	B-1, C-1

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† Models known as " Loaded stream " excepted.
‡ Depending on size.

foam or excessive water. Carbon dioxide extinguishers are preferred for this purpose. Where these are not suitable or available, the carbon tetrachloride is considered next best, with gas masks provided if required.

REFERENCES

CROSBY-FISKE-FORSTER, *Hand Book of Fire Protection,* National Fire Protection Association.

The National Fire Protection Association Standards. (These are made available through the National Board of Fire Underwriters.)

NATIONAL SAFETY COUNCIL, *Safe Practices Pamphlets 24 and 31.*

HENDERSON and HAGGARD, *Noxious Gases,* Chemical Catalog Company.

Organizations from which additional material may be obtained

National Fire Protection Association, 60 Batterymarch Street, Boston, Massachusetts.

National Board of Fire Underwriters, 85 John Street, New York City.

Underwriters' Laboratories Inc., 207 East Ohio Street, Chicago, Illinois.

Factory Mutual Inspection Department and Laboratories, 184 High Street, Boston, Massachusetts.

National Bureau of Standards, Washington, D. C.

National Safety Council, 20 North Wacker Drive, Chicago, Illinois.

National Fire Waste Council, Washington, D. C.

Fire Protection and Insurance Section of the Association of American Railroads, Washington, D. C.

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SAFETY ACTIVITIES

CHAPTER XVI

Compensation Laws

General Comment. The reader is advised to become familiar with the compensation law of the state or states in which he is employed, since wide differences exist between the laws of the various states especially with reference to occupational diseases, amounts paid in compensation, and the employer's responsibility for medical expenses. (The last is limited in some states.) The following discussion deals with the law of New York State, which is one of the leaders in compensation law. The New York Compensation Law was originally passed in 1913 and has since been modified and liberalized by successive amendments. The main provisions of the present law follow.

Exclusive-Remedy Feature. Compensation is designated as the exclusive remedy in all cases of industrial injury, and the employee or heirs cannot elect to sue unless the employer neglects to secure compensation, in which case the employee may elect to take compensation or to sue. In such suits, the employee is not required to demonstrate his own freedom from contributory negligence in causing the accident.

Third-Party Accidents. Where an industrial accident results from the action of a third party, the employees may sue the third party while accepting compensation and treatment from the employer.

Who Must Secure Compensation. All employers, except those specifically exempted, who employ four or more persons, must provide compensation coverage. The exemptions are:

1. Employers of clerical help who do not employ four or more persons in hazardous occupations. (If the employer employs four or more persons in hazardous occupations, compensation must be secured for all employees, including the clerical group.)

2. Employers of farm laborers.
3. Clergy and non-manual employees of charitable and educational institutions.
4. Employers of domestic labor, except chauffeurs in cities of over 2 million people.
5. Work-relief agencies.

Agencies of the state and of political subdivisions of the state must secure compensation (except the work-relief agencies exempted above).

How Compensation May Be Secured. Compensation may be secured by: insurance with the state fund, insurance with an authorized insurance company, or self insurance, upon posting of a suitable bond.

Insurance with the state fund frees the employer from further financial liability; insurance with an insurance company does not. In the event of inability of the insurance carrier to pay compensation, the employer is responsible. Note: if insured with an insurance company that becomes insolvent, the employer is responsible only for payment of unsatisfied claims arising out of his firm's accidents.

Injuries Covered by Compensation. Any injury arising out of and in the course of employment, including an aggravation of a pre-existing condition, is compensable. In practice, every injury occurring on the employer's premises, while working for the employer at another location, or while traveling between jobs, is compensable.

Industrial Illnesses. An industrial illness is compensable if reported within a year of its incidence, or if reported while in the employ of the same employer without time limit.

Exceptions. If the injury is the result of an intent of the injured to cause injury to himself or another, or is solely due to intoxication of the injured, the accident is not compensable. If injured while performing an act which is expressly forbidden, the injury is not compensable. This does not exempt cases resulting from infraction of prescribed methods of doing a job; the entire action must be forbidden to qualify.

Physical Weakness as a Contributing Cause. If physical weakness or condition is the sole cause of injury, it is not compensable, but if the injury is rendered more serious by the industrial surroundings it is compensable. Thus an employee fainting and striking a machine, or becoming entangled in it, receives a compensable injury.

Borderline Cases. Many borderline cases exist that must be individually decided, each on its own merits. Horseplay accidents are thus frequently determined on the degree of culpability of the injured. Accidents and injuries resulting from fights within a plant are frequently decided upon the basis of aggressor or defender position of the injured, upon guilt of provocation, or upon the cause being plant matters or personal differences external to the plant. In most cases of ambiguity or doubt on these matters, decision is in favor of the injured.

Presumptions in Favor of Injured. The law requires the compensation commission to presume in favor of the employee on most contested matters relevant to the case in which doubt exists. Specifically, the law requires that, unless undeniable proof to the contrary is offered by the employer, the commission shall presume in favor of the injured that: (1) notification of employer regarding the accident is within the prescribed time limit, (2) the injury is eligible for consideration under the law, (3) it did not result solely from intoxication, (4) it was not the result of willful intent to injure self or another, (5) proper medical reports are incontestible evidence of the facts contained therein.

Inability to Waive or Assign Compensation. An employee cannot waive compensation either before or after an accident. Compensation payments cannot be assigned, attached, or released, nor can they be commuted except where the commission may commute them to a lump-sum payment.

Notification of Industrial Injury. The employer must report to the commission, on the forms provided for that purpose, every accident resulting in death, amputation, loss of function, or lost time within ten days after its occurrence. The employee must notify the employer and the commission within thirty days after injury. In event of death resulting from injury, employer and commission must be notified within thirty days after death. In occupational disease, notification must be within ninety days of disablement.

This requirement may be waived by the commission if the employer has knowledge of the injury or death, if such notice could not have been given, or if the employer's interests have not suffered as a result of the failure to notify. Objection must be raised concerning failure to notify at the first hearing at which all parties are present. Otherwise the employer is considered to have waived his right to contest on this ground.

Penalty for Objection to Award or Appeal without Just Cause. If objections to an award are entered by the employer or insurance carrier without just cause, the commission (after a hearing) may increase the award by 15 per cent. If an award is appealed to the Appellate Division, and is upheld unanimously, it is increased by 10 per cent.

Basis of Computation of Compensation Payments. Compensation payments are computed on the basis of average weekly wage, which is determined as three hundred times the average daily wage for the days actually worked in the past year divided by fifty-two. For newly hired employees, the average wage of another employee in similar work may be used as a basis.

Based upon the average weekly wage thus determined, the compensation payment is computed according to the following table.

Disability	*Range of Average Weekly Wage*	*Compensation Rate Per Week*
Temporary total or permanent partial	Less than $8.00	Average weekly wage
	$8.00 to $12.00	$8.00
	$12.00 to $37.50	⅔ of average weekly wage
	More than $37.50	$25.00
Permanent total	Less than $8.00	Average weekly wage
	$8.00 to $12.00	$8.00
	$12.00 to $22.50	⅔ of average weekly wage
	More than $22.50	$15.00 (additional $10.00 may be allowed for rehabilitation, paid by state fund)
Fatality		Benefits as outlined in subsequent paragraph titled Death Benefits

(Note: In event a minor is involved, the compensation payments may be based upon a sliding scale, taking into account anticipated normal development and increased earning. In the case of a minor illegally employed, compensation is doubled, with the penalty portion assessed directly against the employer, not against the insurance carrier.)

In April, 1944, a temporary increase in compensation payments was enacted, effective for one year. This increase was based upon the prevailing higher living costs, and it may be anticipated that it will be re-enacted as necessary to continue in force until the cessation of hostilities. The compensation payment under the temporary law is computed according to the following table.

Disability	*Range of Average Weekly Wages*	*Compensation Rate Per Week*
Temporary total,	Less than $12.00	Average weekly wage
permanent partial,	$12.00 to $18.00	$12.00
or	$18.00 to $42.00	⅔ of average weekly wage
permanent total	More than $42.00	$28.00

Period of Payment

Temporary total disability: for the duration of the disability, but not to exceed $5,000 total. No payments are made for first seven days unless the total disability exceeds thirty-five days, in which case compensation is paid from the first day.

Permanent total disability: for life.

Permanent partial disability: for periods as detailed in the following schedule. The period in each case anticipates a reasonable time of temporary total disability, but, if the temporary total disability is excessive, the amount by which it exceeds the anticipated amount is added to the schedule period.

Loss of*	*Period Schedule*	*Plus Temporary Total Disability in Excess of*
Arm	312 Weeks	32 Weeks
Leg	288 "	40 "
Hand	244 "	32 "
Foot	205 "	32 "
Eye, binocular vision, or 80 per cent vision of an eye	160 "	20 "
Thumb	75 "	24 "
First finger	46 "	18 "
Great toe	38 "	12 "
Second finger	30 "	12 "
Third finger	25 "	8 "
Toe, other than great toe	16 "	8 "
Fourth finger	15 "	8 "
Hearing, one ear	60 "	Not mentioned
Hearing, both ears	150 "	" "

* Loss of member includes either amputation or loss of function.

Definitions of Degrees of Disability

Temporary total disability: one which temporarily prevents employment in the same job or another at the same rate.

Permanent total disability: total incapacity for any employment for life, including loss of both eyes, or both arms, or both legs, or any two of these members, in the absence of proof to the contrary.

Permanent partial disability: loss of, or loss of function of, any member; facial disfigurement; and other disfigurements which may prejudice employment.

Medical Expenses. In addition to the above, the employer is responsible for providing proper medical care; this liability is assumed by his compensation insurance carrier. Rates of such expense are limited by ruling, except where the employer of his own volition secures more expensive service.

The employer must furnish crutches, appliances, and artificial members of the body; he is responsible for repair or replacement of all such devices, during the employee's life, as necessitated by normal wearing.

Medical Examination. The physician of the employer is not permitted to be present during examination by the physicians of the Commission, but he may examine the employee immediately thereafter in the presence of the employee's physician.

Death Benefits. In the event of fatal injury, all terminal medical expenses must be paid, plus actual funeral expenses not to exceed $200, plus the continuing benefits based upon actual average wage up to $150 per month (total benefits not to exceed 66 2/3 per cent of actual wage or $100 per month, whichever is the lower). Benefits are distributed in a specified order as follows, dependencies in the lower rank not being considered if higher dependencies absorb the entire 66 2/3 per cent.

Widow receives 30 per cent of wage (maximum benefit $45.00 monthly) during widowhood, plus two-years' lump-sum benefit upon remarriage.

Children (each): receives 10 per cent of wage (maximum benefit $15.00 per month) until age eighteen, or (if incapacitated) for life. Upon death or remarriage of mother, each child's share increases to 15 per cent of wage (maximum benefit $22.50 per month).

Dependent Parents (each): receives 10 per cent of wage (maximum benefit $15.00 per month).

Dependent Grandparents (each): receives 10 per cent of wage (maximum benefit $15.00 per month).

Dependent Minor Brothers or Sisters (each): receives 10 per cent of wage (maximum benefit $15.00 per month) during minority.

Dependent Grandchildren (each): receives 10 per cent of wage (maximum benefit $15.00 per month).

CHAPTER XVII

Safety Organization

DEFINITION

Safety organization may be defined as a well-organized plan the purpose of which is to enlist and maintain the combined effort of the entire personnel of an establishment for the prevention of accidents. The chief operating executive in any well-managed, efficiently conducted, industrial organization is aware of the steps and procedures necessary to establish a system in the organization and to follow it up in order to make sure that any new plan is effectually carried out.

The results obtained by the plant-safety organization will be directly proportionate to the degree of interest and enthusiasm shown by the chief executive. A tremendous responsibility rests upon him for inaugurating and carrying out the various phases of the accident-prevention program. There are many possibilities for mistakes, and many devices that can be adopted will not produce the desired results. Errors in organizing the accident-prevention effort may make it ineffective. For this reason some of the mistakes commonly made will be cited in this chapter in order that those people who are interested may profit by this knowledge.

TYPES OF SAFETY ORGANIZATION

There are many types and variations of safety organizations used in industry. However, they generally follow the patterns indicated in the following four groups.

Type A: Line Organization. With this arrangement all the safety functions are carried on by the regular plant personnel. It has many outstanding advantages. First among these is the fact that the safety work is coupled directly with all other operating problems. It makes safety an integral part of all working processes. It avoids the mistakes, frequently made, of emphasizing safety at the expense of something else. It is sound logic that when a job is done properly the job is also done safely and that the best way of performing any task is naturally a safe way.

Accidents normally are an indication of poor supervision. Where the line organization is competent and adequate to carry its full responsibility all the way down, the safety function may be added without fear of overburdening the supervisors or of not giving accident prevention the necessary attention.

There are some minor objections to this type of organization. First, unless someone is designated by the chief executive to attend outside safety conferences and other meetings, where new ideas and devices are introduced, it will be difficult to maintain contact with the rapid progress being made generally by accident prevention in industry. A second common fault in line organizations is that minor improvements in procedures and equipment that reduce accidents in one department may not become generally known throughout the other departments. Both of these objections may be effectively removed by placing a highly competent safety technician on the staff of the chief executive. With this modification, line organizations prove quite effective in small plants.

Type B: Organization with a Safety Director. This form of safety organization employs, under the command of a safety director, a group of people who are charged with the responsibility of supervising and coordinating the accident-prevention activities in the various departments. It is commonly used in large industrial firms.

The effectiveness of a Type B organization depends primarily upon three factors: the character and qualifications of the safety director, the executive support given him, and the selection and training of safety personnel.

The safety director should be resourceful, competent, and practical. He must be able to secure the cooperation of the production supervisors and department heads, and he must be ready and able to give cooperation in return. His conduct and that of his subordinates must be such as to gain the support of the rank-and-file production employees. If the work of the organization is highly technical in its nature, he must be qualified by training or experience or both to understand the processes involved.

The chief executive must support the safety director in his work, especially in matters in which the expenditure of money is required. These include the safeguarding of machinery, the purchase of protective clothing and equipment, the elimination of fatigue, the correction of ventilation and illumination, and many similar improvements. It is not intended to imply that the safety director should be final judge in such matters, but his opinions and arguments should be equally considered with those of other department heads. The safety director should be consulted on all matters of executive decision with relation to accident prevention. His contact with the chief executive should therefore be direct and personal.

The selection and training of inspectors and other safety personnel are frequently given inadequate consideration. These are the accident preventionists with whom the lower supervisors and the rank-and-file employees have contact, and it is their duty to sell accident prevention at the places where accidents are likely to occur. It is also their duty to bring to the attention of the chief executive, through the safety director, specific recommendations for the control or elimination of accident-breeding conditions. Persons selected for this work should be properly qualified as to character, knowledge, and sincerity. They should be sufficiently trained in the plant processes to be able to understand the work they inspect and to be capable of locating accident sources in that work.

The selection of the individual for the safety director's job is particularly important. It is here that the chief executive frequently makes a mistake. Often a hurried search is made through the organization for an engineer who is not too valuable in the job he is holding, whereupon he is given the title of safety director and is told to get busy and reduce the accident rate. When the individual thus selected is suddenly placed in charge of safety activity with all an engineer's faith in mechanical devices, he sets about learning all he can about machine guarding. From books and catalogues of safety appliances he picks up the language of accident prevention and learns something about the use of goggles, safety helmets, and similar protective equipment. He attempts to cover every machine and worker in the plant with some sort of mechanical safeguard and pleads with the better-paid production executives to cooperate with him. When the accident rate steadily increases, the harassed man then brings in some outside agency to conduct courses in first aid in order that injuries may result in nothing more serious than lost time.

In order to avoid this error, it is suggested that the qualifications of the candidate for safety director be given very careful consideration. Some of the essentials are a thorough knowledge of industrial-accident prevention and ability to install an effective safety-training program for all employees in hazardous occupations, a program that may be conducted not by lecture methods, but by a proven conference-training method. He should have all of the personal qualifications you would expect to find in a successful man in any walk of life. He should have vision, initiative, persistence, judgment, diplomacy, leadership, and sympathy. A college degree is desirable but not essential. The effective safety director knows that his job is a staff function and that he must seek every opportunity to be of service to the members of the line organization without encroaching upon their authority. He must leave their responsibility entirely with them, but he must assist them in any way he possibly can in the carrying out of their responsibility. The effectiveness of the safety director is in almost direct proportion to his ability to secure the confidence and respect of every foreman and supervisor in the plant and to the manner in which he reflects the prestige given his position by the chief executive.

Type C: Safety Committee Organization. In this type of organization the accident-prevention activities are centered in a committee consisting of the heads of various departments. In most cases, the chief executive acts as chairman of the committee, since in this way the committee can be most effective. Safety-committee organizations are most commonly found in small and medium-sized plants.

The committee-type organization is very similar to the line-type; in most cases it has been adopted as a development from and improvement upon a previous line organization. It has two important advantages over the line organization: committee meetings set apart a certain amount of time specifically for the consideration of problems of accident prevention, and they encourage transmission of information between departments regarding improvements which have proven successful in limiting accidents.

The safety committee offers the opportunity for very effective accident prevention, since the various department heads present are enabled to present their individual opinion and, after discussion, arrive at mutually agreeable decisions. Since the chief executive acts as chairman, his official approval can be assumed on any matters agreed upon by the committee, and its decisions can be immediately put in effect.

The committee-type organization depends entirely upon the interest and enthusiasm of the chief executive. If meetings are held regularly and the chief executive makes it a point to attend each meeting and to insist upon regular attendance on the part of the department heads, the committee can be and usually is effective.

The most common causes of ineffective safety committees are: irregular and infrequent meetings, in some cases called only after a serious accident has occurred; frequent failure of the chief executive to attend; failure of the other members to attend; and executive hedging when suggested measures for accident prevention involve additional expense.

Type D: Organization Combining Safety Director and Safety Committee. In this type of organization, the accident-prevention work is commonly carried on by a safety department under the supervision of a safety director who meets with other department heads in the safety committee for the discussion of mutual problems. This plan is now employed by many of the largest industrial concerns.

When this type of safety organization has been decided upon and the safety director appointed, the sequence of the events that follow are usually in this order. Arrangements are made for the preparation of accident records and of accident analysis; charts and graphs may be desired to indicate trends. Facilities for thorough investigation of certain types of accidents are set up, a cause code is adopted, and the procedures necessary to accurately classify accidents according to causes are instituted. An employee-training program is established, usually based on the conference idea, first-aid facilities for all employees are provided, and the necessary employees are trained in the proper use of first-aid equipment. Plant processes are studied and arrangements are made for the purchase and distribution of necessary personal protective equipment and for thorough instruction of all employees regarding the use of equipment furnished to them. A thorough inspection is made of all plants and properties for layout and arrangement, guarding of machinery and equipment, housekeeping conditions, maintenance, and handling of materials. All of these subjects are discussed in detail in other parts of this book.

CHOICE OF TYPE OF SAFETY ORGANIZATION

The chief executive should carefully consider in advance the type of safety organization that he will cause to be set up in the plant. In an existing plant, the personalities of the production department heads should be taken into account, since the safety organization will work with and through them. A fixed rule cannot be established, but certain general principles can be stated.

In a small plant (employing not more than two thousand persons) the choice will usually be between the line and committee types. The determining factor in such a case will be the consideration of the personalities of the department heads. If they are congenial and cooperative, the committee form is indicated, but if they are individualistic or highly opinionated, the line organization will probably be most effective. In either case, the executive should consider the desirability of employing a safety technician to do most of the ground work for him. A safety inspector, trained in a large organization, will usually prove satisfactory.

In a medium-sized plant (employing from two to five thousand persons) the choice is usually between a safety-committee organization and safety-director organization. The determinant will probably be the amount of time the chief executive can personally devote to accident prevention. The committee form, requiring his continuous intimate contact with the work, consumes much more of the chief executive's time; if he is already busy, a safety-director organization will relieve him of a large part of the detailed work and other time-consuming phases of accident prevention. In either case, a number of safety assistants will be required.

In a large organization, the choice is limited either to a safety-director organization or to an organization combining safety director and safety committee. In most instances it is desirable to start with the former and at the appropriate time form the committee to supplement the safety director. In this way the safety director has an opportunity to learn the plant arrangement and processes before he is called into open-committee discussions of specific problems. In the early stage the safety director has the opportunity of becoming acquainted with the department heads and establishing friendly relations with them.

Irrespective of the type of organization chosen, the plant should enlist the services of the National Safety Council by securing membership in it. Safety personnel and supervisory employees should be sent to attend meetings of the local safety council to obtain accident-prevention information. In addition to the safety organization, the plant should employ all means at its disposal to disseminate accident-prevention data. Some of the common supplementary measures are outlined in the following sections.

ADVERTISING

If the company maintains an advertising department, it is well to solicit its services in organizing the safety-advertising campaign, because safety must be sold initially, not only to all supervisory employees and foremen, but to the individual workers as well, and every available device must be utilized in order to accomplish this purpose. It is important that the advertising be made continuous in order to maintain the interest thus created. Such devices as safety posters, bulletin boards, pay-envelope enclosures, calendars, contests, and many similar ones can be employed by management in establishing and maintaining the interest of the employees. Much of this material is available in printed form through the National Safety Council.

DEPARTMENTAL SAFETY COMMITTEE

Departmental committees should be organized only in those departments where accident experience indicates the need for a committee. The committee personnel should include supervisory employees and foremen, with the superintendent or other executive as chairman. The total number of members on the committee should not exceed fifteen and, if possible, should be limited to an even smaller group. The safety director or other safety-department representative should assist the chairman in organizing the new committee and in planning the agenda and meeting schedules. However, this work should be shifted to the chairman as soon as the latter shows ability to handle it. The effectiveness of the departmental safety committee depends largely upon the degree of interest shown in planning and scheduling the various activities to be undertaken.

In addition to the chairman a vice-chairman and a secretary should be appointed. A representative of the safety department should attend each meeting and receive copies of the minutes. All questions that cannot be definitely concluded by the departmental committee should be referred to the executives for decision.

In some cases it has been found effective to include a number of employees below the rank of foreman in the departmental committee, or to form a committee entirely of such employees. These alternatives are necessary if the plant supervisory force is out of touch with the rank-and-file employees.

The agenda for the meeting of a typical departmental committee follows. 1. Ask for approval of the last committee-meeting minutes; omit reading of minutes. 2. Discuss all accidents that have occurred since the last regular meeting, for the purpose of devising methods of prevention and never for the purpose of fixing blame. 3. Review accident statistics and reports. 4. Discuss unusual accidents occurring in other departments of the company or in other companies. 5. Call for reports of sub-committees or other special assignments. 6. Develop recommendations on the previous items. 7. Have a report by the safety representative of any work assigned to him or of any new activities that are contemplated.

One of the methods used in departmental committee meetings is to assign topics to various committee members ahead of time in order that they may study the subjects and present brief discussions at later meetings. These topics should be well chosen and timely and should have direct bearing on the work of the committee.

The preparation of safety posters that apply specifically to the hazards encountered by the workmen represented on the committee is very desirable. Photographs of the right method of performing a certain job may be prepared. Pictures of individuals who are known to the employees make such posters more interesting.

Committee members should be encouraged to bring their problems and questions to the committee for discussion. All meetings should start and adjourn promptly.

Arrangements should be made whereby the committee personnel should participate in all of the other safety activities being conducted in the department. This may include the preparation of material for lectures to be given, the selection of pictures to be taken, or the presentation of information that is directly related to the overall plant-safety program.

Safety suggestions that are obtained from the committee members should be inserted in the minutes and, if desirable, transmitted to the regular suggestion system of the company for ultimate disposition.

The committee personnel may remain permanent when only a small group of employees is involved. However, in a larger group it may be desirable to rotate the committee members according to a predetermined plan, in order that a large number of employees will participate and have the advantage of the educational possibilities offered by serving on this committee. Committee members must be thoroughly convinced that no safety program can function without the wholehearted support and cooperation of every employee. It is therefore their duty to pass along to their co-workers or subordinates all information of value to their groups.

It is the responsibility of the safety director to review the work of departmental committees at various times in order to determine whether or not they should be continued. Most of these meetings are held on company time and therefore should be discontinued when the real need for them has ceased to exist. However, other factors (such as labor turnover, changes in job process, and similar items) should be taken into consideration before the committee is disbanded.

CHAPTER XVIII

Plant Inspections

Each supervisor in a plant is charged with full responsibility for the actions of all persons and the operations of all machines placed under his direction. To discharge this responsibility adequately the supervisor must continuously inspect the machines to assure that they are in good operating condition and are being properly operated. He must continuously inspect operations to assure that productions flow smoothly and on schedule, that employees are neither overworked nor idle, and that prescribed methods of performing work are being followed. He must be continuously aware of conditions within his department and take positive steps to avoid potential causes of work stoppage, whether they are material shortages, accidents, fires, labor disputes, or any of the other possible disturbances that may interrupt production.

Obviously, the supervisor cannot be sufficiently expert in all fields to perform adequately the duties which these responsibilities infer. He must be assisted in many of the functions by specialists in the various fields. This can be done by assigning to each supervisor a staff of specialized subordinates or, as is more commonly done, by centralizing the specialists in staff groups which are then available to any of the supervisors for consultation and advice on the solution of specific problems as they arise. In small industries, where it is not possible to provide the staff groups, the more difficult special problems are often referred to outside consultants, routine problems being handled internally with such forces as are available.

With reference to the supervisor's responsibility for accident prevention, two forms of assistance are generally available. These are the services of the plant safety department on all general matters of accident prevention, and certification (based on outside expert inspection) of the condition of certain equipment or devices. The most common examples of the latter are the periodic inspections of boilers and other pressure vessels, and of elevators; these inspections are required by law or by contractual agreement with insurance carriers. In many plants, certifications based upon expert inspection are voluntarily secured on the most important production machines as a safeguard against machine failures.

Wherever such expert inspections are made, whether mandatory or voluntary, they relieve the supervisor of a part of his responsibilities. Certifications give reasonable assurance that, if the equipment is properly operated and is not damaged by accident, it will operate satisfactorily at least until the next scheduled inspection period. These inspections, however, place a moral (and in some cases legal) responsibility upon the supervisor to investigate all occurrences that may have damaged the equipment and to cause necessary repairs to be made and the equipment reinspected before restoring it to service.

Safety-Department Inspections. Safety-department inspections of equipment and operations are a major component of the assistance which the safety department can and should give the production supervisor. They, in effect, " spot check " each supervisor in the performance of his accident-prevention work. They do not in any way relieve the supervisor of any part of his responsibility for preventing accidents. They enable the safety department to learn the hazards of the operation and to assist the supervisor in eliminating these hazards, reducing exposure, or protecting employees.

It should be realized that the safety-department inspections are parts of a cooperative effort and not interferences with operation or attempts to find fault. The very nature of the inspections makes for misinterpretation of their purpose; in fact, many safety inspectors have a wrong concept of their own work. The safety department should make positive efforts to establish and maintain, in the entire operating group, a proper appreciation of the intent of the inspections. The safety director should watch closely the manner in which inspections are made and the nature and form of the inspection reports.

Scheduling of Safety-Department Inspections. Safety-department inspections should be scheduled at irregular intervals so that the inspector will see operations proceeding in their normal manner, rather than ones that are staged for his benefit. Upon arrival in the area to be inspected, the inspector should make his presence known to the production supervisor of that area, thus avoiding any appearance of " sneak " inspection.

Preliminary Preparation for a Safety-Department Inspection. Much time will be saved and better results obtained if the following preliminary preparations are made before the inspection.

1. Assemble in advance all of the pertinent accident facts concerning the department to be inspected. The accident record should be examined to determine the frequency and severity rates, the locations of accidents in the plant, the nature of the injuries, and similar data.
2. Reports of previous inspectors should be examined, their recommendations noted, and a check made of the disposition of the previous recommendations.
3. It is desirable for the inspector to have complete knowledge, or at least a good working knowledge, of the operations, processes, and materials used.
4. The inspector should determine what authority, if any, is granted to certain employees to operate dangerous or hazardous equipment, by whom the authority is granted, and under what conditions.
5. It is essential that the safety inspector wear the protective clothing and safety devices normally provided for the employees working in the area where the inspection is made; he should equip himself accordingly.
6. If the inspection is to cover an entire building, it is necessary that the inspector know the general arrangement of equipment and the material flow. These should be studied (or reviewed) prior to the inspection.

Notebook. The notebook is essential for the inspector's use, but it should be discreetly used. It should not be carried in the inspector's hand, since, if it is thus carried, it gives an appearance of snooping and causes distrust. When an entry is required, it should be openly made, and, if the entry refers to a condition that the inspector has discussed with one of the operating employees or supervisors, that person should be informed of the entry and its intended use. This avoids possible embarrassment in the event the person does not wish to be quoted or mentioned. Any information given in confidence should be treated confidentially.

Safety inspectors should develop the habit of making terse notes to avoid spending too much time in writing in the notebook. Three or four words in reference to a condition should be sufficient in most instances to refresh the memory of the inspector when he prepares his written report.

Inspection Technique. The safety inspector is an outsider in the area he inspects. His actions are subject to criticism by the production supervisor of that area if they disturb or hinder production in any way. If it is possible to do so, the inspector should make his tour through a department in company with a supervisor of that department. This eliminates any risk of direct interference and permits immediate correction or discussion of conditions which the inspector may observe. The inspector should fully realize that he has no supervisory function and should refrain from giving orders to any employee unless that employee is exposed to a severe risk of death or a serious injury.

If the inspector can establish cordial relations with the employees, it is desirable that he should do so, but he should not engage in lengthy conversation with individuals or groups, since this keeps them away from their work and thus interrupts production. Even if an employee tries to prolong a conversation, the inspector is likely to be criticized for permitting it since he is usually considered the more responsible person.

The inspector should attempt to have any minor faults, that he may observe, corrected. This should be done by contacting the supervisor and suggesting to him the correction required. As an example, the supervisor can remove from service unsafe tools, ladders, or other small equipment, and cause them to be repaired or destroyed. Immediate treatment of such condition removes the necessity for an interdepartmental letter detailing the situation, eliminates the opportunity for an accident which might occur before such a letter could be transmitted, and avoids the need for rechecking the same condition at the time of the next inspection.

Observed unsafe acts of employees, or violations of prescribed procedures, should be corrected if possible through the supervisor. Where it is necessary for the inspector to intervene directly (as in a case where the hazard of severe injury is present), the inspector should discuss the matter with the supervisor as soon as possible after the incident.

It is generally unwise to attempt to stop an unsafe act in midstride, since to do so distracts the attention of the employee and may provide sufficient additional accident cause to permit the possible accident to occur. It is better in most cases to wait until the acute hazard associated with the action is past before attempting correction.

Check Lists. A check list is a tabulation of the specific conditions, machines or machine parts, and operations which the inspector is to observe in his inspection. Such lists are extremely helpful in locating physical hazards and have the additional benefit of causing good or excellent conditions to be reported as well as poor conditions. This, to some extent, removes the fault-finding impression created by a report that mentions only defects observed.

The use of check lists may tend to stifle the originality of the inspectors. This can be avoided by requiring the inspectors to submit textual reports in addition to the lists.

The following are suggested items for a check list covering the general inspection of a plant or a department within a plant.

CHECK LIST

1. *Housekeeping*
   - Condition of outside ground
   - Condition of floors and stairs
   - Condition of windows
   - Material storage
   - Aisles, adequacy
   - Aisles marked
   - Drip pans for oil or grease drips
     - Provided where needed
     - Maintained
   - Receptacles for scrap and waste
     - Provided where needed
     - Regularly emptied
   - Tool storage
     - Tool room
     - At machines
   - Toilets and other sanitary facilities
   - Drinking fountains

2. *Machinery*
   - Equipped with adequate guards
   - Guards in place
   - Non-repeat devices
   - Lock-stop devices
   - Accessibility for oiling and repair work

3. *Fire Protection*
    - Extinguishers
        - Suitable types
        - Condition
        - Locations, suitable
        - Inspected within proper period
        - Employees trained in use
    - Exits and escapes
    - Sprinklers in good condition and unobstructed
    - Storage of flammable or explosive materials

4. *Hand Tools*
    - Good quality
    - Condition
    - Kept in place
    - Used for proper purposes

5. *First-Aid Facilities*
    - Quarters
    - Properly equipped
    - Trained attendant
    - First-aid kits in accessible places

6. *Equipment Requiring Periodic Inspections*
    - Dates of last inspection of
        - Elevators
        - Boilers
        - Unfired pressure vessels
    - Maintenance and operating procedures

7. *Overhead Hazards*
    - Cranes, hoists, derricks, chains, and ropes
    - Wiring
    - Loose objects on beams or other high places

8. *Electrical Equipment*
    - Proper wiring, permanent repairs
    - Grounding of equipment
    - Extension cords
    - Fuse boxes locked or sealed

9. *Material Handling*
    - Trucks and hoists for heavy objects
    - Gloves for sharp objects

10. *Protective Equipment:* Goggles, Respirators, Gas Masks, Safety Shoes, Gloves, Aprons
    - Good quality
    - Properly used
    - Available where needed
    - Condition

11. *Lighting*
    - Adequate
    - No shadows or glare

12. *Ventilation*
    - Adequate
    - Temperature and humidity control
    - Sources of air
    - Venting

13. *Gases, Dusts, Fumes, Vapors*
    - Properly eliminated or exhausted
    - Contaminant properly removed at discharge
    - Gas masks or respirators available
    - Protective clothing, supplied and worn
    - Explosion hazard

14. *Portable Ladders and Scaffolds*
    - Good quality
    - Adequate for work
    - Good maintenance
    - Sufficient number available
    - Storage conditions
    - Properly used

15. *Accident Records*
    - Analysis, trends, comparisons

Unsafe Practices. Unsafe practices are more difficult to detect and correct than physical hazards, since in many cases they appear only at certain parts of the operations. The inspector must witness the specific acts in order that he may become aware of the hazards involved and initiate corrective action. In consequence, a particular unsafe practice may be followed for a long time before the safety department becomes aware of it. Frequently such a practice is not brought to the attention of the safety department until an accident has occurred and the practice is disclosed by the accident investigation.

Unsafe practices that are generally and frequently followed may be detected in the course of inspection. Some that may be found in this manner are: persons operating hazardous machinery without authorization, or with inadequate knowledge and training; persons working at unsafe speeds, or using short-cut methods; guards removed, rendered ineffective, or not used; tools and equipment used improperly, or in defective condition; overloading of storage space, or storage in aisles or working space; employees standing under or riding suspended loads; employees jumping on or off moving vehicles; oiling, adjusting, or repairing equipment in motion, or without adequate protection to prevent starting; horseplay; employees distracting or startling co-workers; failure to use protective devices or wear protective clothing.

In most plants the above unsafe practices are flagrant violations of established work procedures. Where they are followed, supervision is inadequate or improper.

Unsafe practices that result from poor work habits of an employee, and those that are allowed to develop because of inadequate job analysis or training, are more difficult to detect and usually are not observed in general inspections. If they are suspected, an inspector may be assigned to study the individual employee at work, or the specific job procedure.

Starting and quitting times, and the beginning and end of the lunch period, are intervals during which unsafe practices are frequently obvious. Special inspections should be arranged occasionally to witness activities at these hours.

Inspection Reports. The report of an inspection should reflect the general condition observed. It must detail the hazards noted, but it should not overstress them or convey the impression that nothing but faults exist.

It was previously stated that, during the course of his inspection, the inspector should attempt to secure correction of observed hazards, or should discuss the hazards with the supervisor. If a specific hazard, such as a defective tool, was effectively removed on the supervisor's order, that fact should be included in the report. If a hazard was discussed with the supervisor but correction was not made, the supervisor's reasons for not correcting it should be included. When all the facts are presented in this manner, needless rechecking of conditions that no longer exist is avoided, and corrective action on those hazards which were not eliminated can proceed more intelligently because of the increased knowledge of the surrounding circumstances.

The safety director, in using the reports of inspectors, should not violate the confidence placed in the inspectors by plant employees, nor should he reverse their decisions on the elimination of a hazard without adequate reason. In the latter instances the inspectors concerned should be informed of the basis for reversal and permitted to convey the thought back to the supervisors. In this manner, confidence in the entire safety department can be fostered, and the cooperation of the operating supervisors may be obtained.

Special Safety-Department Inspections. In addition to general inspections of the various departments, the safety department should conduct special inspections of work involving peculiar hazards.

Maintenance work in general exposes the maintenance crew and operating employees to more serious risks of injury than normal plant operations and should be given proportionately more attention. Maintenance materials and tools in storage or in use should be regularly inspected by the safety department. Maintenance work in progress requires almost continuous inspection to assure that mutual risks to operating and maintenance personnel are eliminated or minimized.

Specific inspections of materials handling work are desirable at frequent intervals. Material shortages, transportation difficulties, or changes in the packaging of raw materials may suddenly create new and serious accident or fire risks in materials handling operations. The safety department should become informed of the changed conditions as soon as possible; this is most practically done through observation of the conditions on inspections.

Safety Inspection in Small Plants. In small plants that do not employ full-time safety inspectors, the principal safety-inspection function is usually placed directly upon the foremen. This is frequently done by supplying check lists and requiring each foreman to fill out and return a check list at regular intervals, usually each week. The check-list inspections are supplemented by occasional inspections made by the safety technician or chief executive.

Insurance Company Inspections. The compensation insurance companies periodically inspect the plants they cover. These inspections do not in any way relieve the supervisory force or the safety department of their respective responsibilities, but are supplementary to the work of these groups. Such inspections are often of great value, bringing to the plant the benefits of the insurance company's wider experience. Suggestions based upon these inspections should be very seriously considered and adopted if at all possible.

INSPECTIONS BY CIVIL AUTHORITIES

Many inspections of plants are made by civil authorities for the purpose of enforcing laws and ordinances. The following list of such inspections that are conducted in the city of New York may be considered typical of law enforcement inspections in most large cities.

LEGAL AGENCIES THAT NORMALLY MAKE PLANT INSPECTIONS IN THE CITY OF NEW YORK

Municipal Department of Building and Housing. This department inspects for compliance with city ordinances regarding exits, fire escapes, fire retarding construction, sprinklers, and similar matters, approves plans for new buildings and supervises their construction, and inspects and approves elevators and boilers.

Violations are prosecuted in the Magistrates Court.

Municipal Department of Licenses. Licenses are granted to certain establishments including hotels, restaurants, bakeries, and laundries. These establishments are inspected for compliance with license requirements and limitations. Violations may result in withdrawal of license or refusal to renew licenses.

Municipal Board of Health. Permits to food manufacturing, handling, or dispensing establishments are issued. Compliance with city ordinances covering these matters is assured through inspection. Violations are prosecuted in the Magistrates Court.

Municipal Fire Department. Permits for the storage of combustibles, and for welding, spray coating, and similar hazardous occupations are granted. Violations of the ordinances related to these matters, and also those having to do with fire protection and exit facilities, are checked in inspections. Violations may be prosecuted criminally.

New York State Labor Department. Compliance with the labor and factory laws is assured through inspection. The construction and demolition of buildings are supervised. This department may also order alterations of buildings and equipment. If violations are noted, the factory can be closed, and criminal prosecution can be started in the Municipal Term of the Magistrates Court or in the Court of Special Sessions.

REFERENCES

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Crosby-Fiske-Forster, *Handbook of Fire Protection,* National Fire Prevention Association.

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CHAPTER XIX

Accident Reports and Records

Reports of serious personal-injury accidents are required in most states to comply with the Workmen's Compensation Law. In most plants, brief reports are required on minor-injury accidents and on certain non-injury accidents. All serve as a basis for analysis of the accident problem as a guide in planning and directing accident-prevention activities. They are also useful for many other purposes. One of the most important is to stimulate and maintain the interest of the chief executive, the supervisors, and the rank-and-file employees in accident prevention.

Standards. Those interested in the compilation of data on industrial accidents should obtain copies of the *American Standard Method of Compiling Industrial Injury Rates* from the American Standards Association. The number of this standard is Z 16.1, 1937, and its cost is 20 cents. This code describes in detail the approved standard method for compiling accident statistics. (See Appendix I.)

One of the chief advantages of preparing statistics on a standard basis is that it permits comparisons with other industries and other companies, since this code is generally used throughout the United States.

Report Forms. The reports of individual industrial accidents are, in almost all plants, initiated by the foremen or other supervisors. There are two general types of such reports. The first contains information on the accident similar to that required by the compensation commission; however, it omits detailed data on marital and dependency status. This type of form is almost universally used.

The second type is relatively new and is specifically designed to stimulate accident prevention. In this type, the chief interest is in the causes and sources of the accidents and the possible means of preventing repetitions.

The forms on pages 174-175 are examples of the two types.

Preparation of Reports. Supervisory employees and foremen should be strongly impressed with the importance of preparing reports of all injuries, however slight, in which the skin is broken or other tissue damaged; the danger of infection exists in every such case. Enforcement of this policy requires strict supervision and a continuous follow-up. Minor-injury accident reports should not be misused. Any attempt to penalize injured employees or to focus attention upon an excessive number of minor injuries occurring in a department will result in a tendency to avoid reporting the cases.

Minor-injury accidents are frequently called "first-aid cases." Reports of them do have considerable value, in that often they indicate the need for preventive devices or other precautionary measures that should be taken. For instance, in one company that was manufacturing wood lasts, the need for proper finishing of the last was indicated by the number of first-aid cases, caused by splinters, that were reported.

ORIGINAL REPORT OF ACCIDENT

DATE TIME

NAME______________ Date of Accident______________

ADDRESS______________ Reported to Foreman______________

______________ Reported to Med. Dept.______________

____

CLOCK NO.__________ DEPT.__________ OCCUPATION__________

WHAT DOING WHEN INJURED
AND DESCRIBE WHAT HAPPENED:______________________________

____

____

Part of body injured______________________________

Nature of injury______________________________

REMARKS:______________________________

____

______________ ______________
SUPERINTENDENT'S O.K. FOREMAN

INVESTIGATION OF ACCIDENT AND REPORT ON PREVENTIVE MEASURES APPLIED

Plant or office______________________________Case no.__________
Give location

Name of injured____________________Date of accident__________

What was the underlying cause of this accident?__________________

____

____

____

____

Guide for Determining Cause of Accident (Check)

Faulty instructions
Inability of employee
Poor discipline
Lack of concentration
Unsafe practice
Mentally unfit
Physically unfit
Improper or lack of guarding
Poor housekeeping
Defective equipment or materials
Unsafe building conditions
Improper working conditions
Improper planning
Improper dress or apparel

Give your opinion how accident could have been prevented__________

____

____

____

What was responsible for the accident? (Check one) Supervision Human behavior Unsafe condition

What is being done to prevent a similar accident?________________

____

____

____

Accident-Source Classification Key (Check)

Around machinery
Eye injuries
Falls
Handling objects and materials
Burns
Stepping on or striking against objects
Hit by falling objects
Injuries with hand tools
Miscellaneous

Report made by______________________________Date__________
State position with company

Noted by______________________________ " __________
For safety committee

" " ______________________________ " __________
For department head where accident occurred

" " ______________________________ " __________
For superintendent

This report to be completed by person designated by the superintendent immediately after the original report of accident has been made out.

One copy to be sent to the industrial relations department for every accident reported on the form for the original report of the accident.

Prepare such copies as may be desired locally for accident-prevention purposes.

Medical Report. In every accident, whether minor or severe injury results, the employee should receive proper medical care and a medical report should be prepared. This report should cover:

Identification of the injured person and of the accident
A complete description of the injury
An estimate of the time to be lost
Permanent disablement or disfigurement, if either is anticipated.

The medical authorities should prepare a supplemental report each time the employee is examined or treated and should prepare a final report at the end of the treatment.

Correlation of Reports. For every accident reported either by the foreman or the medical authorities, a corresponding report from the other source must be submitted. It is usually the responsibility of the legal authority or other designated authority to insure that both types of reports have been prepared. The legal authority is required to furnish certain information on each accident to the state compensation commission and in most states a time limit is put on this operation.

In most organizations, duplicate copies of the foreman's report and of the medical report are submitted to the legal authority, and to the safety director.

Frequency. The term lost-time accident has always been difficult to define. There are many variations in the definitions used. It is suggested that the methods proposed in the 1937 A. S. A. Code for Compiling Injury Rates be employed. The code defines six classifications of industrial injuries in items 2.2 to 2.7 inclusive. Of these, four are lost-time types which are recommended for inclusion in the computation of accident statistics for general comparisons between companies. The lost-time types include fatalities, permanent total disabilities, permanent partial disabilities, and temporary total disabilities. The remaining injury types, temporary partial disabilities and first-aid cases, are recommended for inclusion only in interdepartmental statistics within a single plant, or between plants where comparable data are available. (For definitions of the injury classifications mentioned, refer to Appendix I.)

In a given plant the number of injuries will depend upon the number of persons exposed to accident risks, the degree of exposure, and the period of time for which each person is so exposed. In order to make possible ready comparisons between the accident experience of different plants, a unit of lost-time accident frequency has been adopted. This is the number of lost-time injuries per million manhours worked by all employees. This is computed by the following simple formula:

$$\text{Frequency} = \frac{\text{number of lost-time injuries} \times 1{,}000{,}000}{\text{manhours worked}}$$

If the frequency rate in a plant, as determined from the above formula, is greater than ten, it is usually possible to bring about a sharp reduction by stimulating the entire accident-prevention program; if it is less than ten, the accident experience is reasonably good and the progress is slower. Such frequency rates are found almost exclusively in plants that have well-established accident-prevention programs, and reductions are only obtained by the cumulative effect of continued effort. Most small plants are not aware of the accident problem because, to them, a frequency rate of ten or greater means only one or two lost-time injuries each year.

The frequency of lost-time injuries is recognized as the best index of a plant accident-prevention performance. It is the accepted standard of comparison of accident-prevention activities among departments in one plant or among several competing plants. The annual awards of the National Safety Council are based on the frequency rates of the competing plants.

Severity of Lost-Time Accidents. In addition to the frequency, another index is required to measure the time loss resulting from accidents. This is known as the severity rate, which is the number of days of lost time per thousand manhours worked and which is computed by the formula

$$\text{Severity} = \frac{\text{time lost in days} \times 1{,}000}{\text{manhours worked}}$$

The frequency and severity rates are not normally related. Identical accidents may have widely varied results in extent of injury inflicted. For this reason severity rates are not used for comparative purposes. They are, however, a necessary supplement to the frequency rate. Since frequency can be altered favorably by failure to report minor lost-time cases, a low frequency rate is subject to suspicion unless the severity is correspondingly low.

In computing time lost due to fatalities and permanent disabilities the Scale of Time Charges, Section 4.1 of the American Standards Association Code, is used. (See Appendix I.)

Statistical Reports. The person responsible for promotion of accident-prevention activities in the plant should prepare various types of reports based upon the analysis of injuries sustained by employees during the report period, which is usually a calendar month. The four types of reports most commonly prepared are as follows.

1. Reports that reflect the accident experience of the entire plant and of each department individually are prepared for the executives of the plant. Reports of this type usually show for each department: the manhours worked, number of lost-time accidents, number of man-days lost, the frequency and severity rates, and the direct costs of accidents. Frequently a comparison is made with the frequency and severity rates of the preceding month or of the same month in the preceding year. Since the report must be brief, in most plants the facts are presented in the form of a table. This facilitates interdepartmental comparisons and acquaints the executives with the relative accident-prevention effectiveness of the various departments.

2. Reports that are prepared for department heads and their staffs include the accident summary described above and a brief but complete history of each lost-time accident.

3. Reports that are prepared for foremen and other supervisors usually omit all cost figures but include comparisons of the frequency and severity rates in the various smaller groups within each department. These reports also include the history of each lost-time accident.

4. Reports that are prepared for rank-and-file employees must be extremely simple since these employees will not spend any large amount of time in studying them. Bar charts of frequency and severity rates of the specific department, or other forms suitable for bulletin-board presentation, are commonly employed.

Cost of Accidents. In computing accident costs, there are two figures to be considered: the direct cost and the indirect cost. Normally the direct cost includes only the compensation payments and medical expenses. The compensation cost for the time lost is readily available. The medical expense includes the hospital, medical, and surgical fees and the cost of such devices for rehabilitation as trusses and false limbs; these costs are usually available.

In most cases, compensation-insurance carriers will furnish this information on request.

Average costs of the various types of lost-time injuries can be used for estimating the probable costs of current cases since the actual costs are not determinable until the cases are closed after full recovery or maximum rehabilitation of the injured persons. These average cost figures can also be used in instances where the insurance carrier does not release exact figures. Thus a simple rule for industrial injuries occurring in New York State, based upon average costs, is as follows.

Type of Injuries Sustained	*Average Direct Cost*
Fatalities	$ 6,300.00
Permanent total disabilities	18,700.00
Permanent partial disabilities (major)	5,400.00
Permanent partial disabilities (minor)	610.00
Temporary total disabilities with full recovery	215.00

The last item includes most of the lost-time accident cases. A similar rule can be developed for any other state. Using this rule, approximate costs can be assigned to the lost-time cases, the cost in each instance dependent only upon the general classification of the severity of injury.

The indirect accident costs are very difficult to determine and are usually arrived at by the application of some percentage figure or ratio. These costs include the time lost by foremen in investigation, time lost by fellow workers in assisting the injured or in their sympathy or shock, time of the first aider, damage to machines or tools and spoilage of work, possible halt in the production line, interruption of production, need for substitute employee (possibly the foreman will be required to work as machine operator for the period of recuperation), loss of part of employee's productivity for a period after his return to work, and many other miscellaneous items.

In 1926 Mr. H. W. Heinrich of the Travelers Insurance Company established a four-to-one ratio between indirect and direct accident costs. This was based upon the study of several thousands of accidents, picked at random and traced to the source. Since the ratio has apparently increased, at the present time it is probably closer to five to one.

Using the four-to-one ratio as a conservative basis, an approximate total figure for accident costs, both direct and indirect, may be obtained by multiplying the direct cost by five. It should be remembered, however, that this is an average figure ratio which cannot be applied to individual cases as there will be wide deviations above and below this figure. As applied to the total direct accident costs for the plant, it is a very effective tool to use in determining to what extent management is justified in spending money for the prevention of accidents.

Analysis of Accident Reports by Individuals. One of the problems of the accident-prevention group is the accident-prone employee. This person is not difficult to locate provided a system has been established to record accident cases individually, according to the name of the injured. It may be necessary to install a separate card file for posting the individual cases. A review of these records should be made every six months, and those of employees who have had frequent accidents should be taken out for further study. The analysis of these cases should be made only by a competent person. Any action taken should be based upon the types of accidents reported. For example, if an employee knew he was particularly susceptible to foreign bodies in the eye, and, knowing he is required to report such injuries, would report them faithfully, he would have a much larger number of accidents reported than the average employee. Consideration should be given to the use of goggles or other protective measures in these specific cases. However, the primary concern of the accident-prevention group is to isolate the cases of genuinely accident-prone employees. These are usually subject to the awkward, clumsy, dropping, falling, and slipping types of accidents. A careful investigation of each such employee should be made and special consideration should be given where evidence of improvement is shown.

The corrective measures to be taken for accident-prone employees will vary with the individual cases. Some of the most useful correctives are change of employment, medical treatment, additional training, elimination of fatigue, change of hours, and improvement of home conditions.

CHAPTER XX

Cause-of-Accident Code

Codes for classifying accidents by causes are designed primarily for use in analyzing accidents. The application of a cause code focuses attention upon the events that preceded the accident and usually requires some investigation to assemble sufficient facts to use the code intelligently.

When the basic cause has been determined and coded, the statistical analysis may be planned to suit the individual needs. Some suggested methods are shown in the chapter, "Accident Reports and Records." Usually a fairly large number of accident cases are selected for analysis. When the analysis has been properly made, it provides many valuable guides for planning accident-prevention activities. The American Standards Association Code, Compiling Accident Causes (Z16.2 – 1941, Parts I & II), is the accepted national standard.

While cause-of-accident codes are used primarily for statistical analyses, they also have a secondary or educational purpose that is of considerable value in accident-prevention work. The use of the code by supervisors and safety committees makes a thorough investigation of the accident necessary and focuses attention on the basic cause. It also assists in maintaining the interest of those employees in accident prevention. We may, therefore, consider the use of these codes as an educational device, as well as a statistical procedure.

Accidents are coded according to causes for various reasons. They are used primarily by the safety director as a guide in planning the activities of the accident-prevention program.

The safety director is normally responsible for developing material and for selecting certain types of hazards or conditions toward which corrective measures are to be applied. The tabular results of the code analysis provide a useful tool for this purpose.

In many plants the supervisors and foremen are required to assign the proper code number to all accidental injury reports for employees under their supervision. This procedure makes it necessary for the supervisors and foremen to secure additional facts pertaining to the incident in order to enable them to classify and assign a code properly.

The assembling of pertinent facts and the development of a brief history of the series of events immediately preceding the accident provide a source of valuable material for discussion at the meetings of the departmental safety committee.

A safety director can easily detect the foreman or group of foremen who consistently try to cover up the real causes of their accidents and who attempt to assign codes that indicate employee responsibility. An excessive number of accidents coded in this manner will usually indicate to the safety director that many such accidents are obviously a failure of supervision (at least in part). The safety director can then follow up these cases and use the corrective measures at his disposal.

The thoroughness and skill with which classification codes are used in the various departments are indications of the foremen's attitude and interest in accident prevention. The safety director will find that time and effort expended in bringing all departments up to a uniformly high standard will be well worth while.

In cases where facilities for statistical analyses are limited, the use of the standard code may not be warranted. In such cases, a brief, short-form code, similar to the following, or a somewhat more elaborate code (such as would be suggested by the accident causes listed on the accident report form, page 175) may be employed.

INDUSTRIAL ACCIDENT CODE CLASSIFICATION

Causes of Accidents

1. Physical condition (employee)
2. Poor housekeeping
3. Defective equipment, construction, or design
4. Improper use or handling of tools or equipment
5. Proper safety appliances not provided or used
6. Improper or inadequate instructions
7. Inattention
8. Failure to observe rules or orders

DEFINITIONS

Physical Condition. It is the responsibility of the employee to report promptly to his supervisor any unusual physical condition. It is the supervisor's responsibility to observe his employees constantly for unusual physical condition and, if any unusual condition is noticed, to send such employees to the medical department for examination immediately.

Only those accidents which result directly from the employee's physical condition should be classified in this group. Examples 1 and 2 (following) illustrate two common types of accidents which are often classified wrongfully as physical condition; example 3 illustrates proper application of this code.

1. Strains caused by improper lifting. Cause: improper or inadequate instructions.

2. Sprains or strains caused by lifting objects beyond employee's capacity when ordered by foreman. Cause: improper or inadequate instructions.

3. When the investigation discloses that an employee was injured on account of some inherent weakness previously known the cause is classified as physical condition. The specific responsibility depends upon the circumstances arising out of the case: *(a)* If an employee has returned to work with a notice from the doctor indicating that such employee should be assigned to light duty and the supervisor provides employment contrary to the stipulation and an accident occurs, it shall be classified as supervisory responsibility. *(b)* If an employee returns to work having previously suffered from injuries or illness and having failed to acquaint his supervisor with such physical condition and suffers an injury by reason of the supervisor being ignorant of such condition, the employee is responsible.

Poor Housekeeping. This classification will apply where accidents are caused as the result of wet, slippery, oily, or dirty floors; or where tools, rubbish, materials, or equipment are stored or left in such condition or location as to cause an accident.

Defective Equipment, Construction, or Design. This classification will apply where accidents are caused by broken, improperly tempered, or mushroomed tools, splintered handles, and defective devices or equipment. It will likewise apply where the accident is caused by a defective condition which, if careful inspection and maintenance had been enforced, could have been corrected. This applies to any permanent or temporary equipment or parts thereof used throughout the company's operations. It also applies where there is a defect in design of permanent apparatus or equipment and includes inadequate and improper lighting. Accidents caused by flaws in tools or equipment, structural faults, or faulty design discoverable under ordinary tests shall also be classified under this heading.

Improper Use or Handling of Tools or Equipment. This classification applies when the improper tools are provided or used, also when any tool, equipment, or material is improperly handled or used.

Proper Safety Appliances Not Provided or Used. This classification will apply where a person has failed to use the protective devices provided, where such devices were not provided, or when such devices were improperly used.

The items considered in this group are goggles, rubber insulation (such as gloves, sleeves, pigs, and blankets), safety belts, trench bracings, cable protectors, respiratory equipment, kick-boards, barriers, portable illuminating devices, etc.

Improper or Inadequate Instructions. This classification is used when the injured person has had insufficient experience or has received insufficient training for the work. It is also used when the injured employee has not been forewarned against the hazards, when he has not been trained in the method of protecting himself and other persons against these hazards, and when the accident has been caused by the giving of incorrect or insufficient information relating to the proper completion of the job or by an employee who has been assigned to unfamiliar work or given incorrect methods for completing assignments. This also includes inaccuracy of expression in stating instructions or failure to understand if instructions were correctly stated.

Inattention. When an employee is properly trained, instructed, and experienced, but an accident occurs because of his mental failure or some other reason of a like nature, the accident shall be classified under this heading only after a thorough investigation fails to reveal any more definite cause.

Failure to Observe Rules or Orders. This classification applies when a person has disregarded orders, rules, or warning by his foreman or others. It includes accidents caused by fooling or playing during working hours. It also applies to accidents caused by willfulness and intemperance.

CHAPTER XXI

First-Aid Facilities

When an accident has occurred, the nature of the resultant personal injury is largely a matter of chance and is generally uncontrollable. After an injury, the extent of the immediate and final damage to the body of the victim is directly dependent upon the treatment administered and is to a very great degree controllable.

Once the accident victim has been placed under the care of a doctor, it may be assumed that, from that moment on, his treatment will be the best that medical science has discovered for his injury. But, in the period between the occurrence of the injury and the arrival of medical assistance, the victim is under the care of non-medical persons. This is when the injured person may be treated by first-aid methods.

It can be demonstrated that proper first aid saves the lives of many accident victims each year. Thousands of victims of electric shock, gas poisoning, and drowning have been saved by the prompt application of artificial respiration. Other thousands are saved through the use of tourniquets and through proper treatment of profound nervous shock. Many more fatalities could be averted by proper first aid, and perhaps many fatalities which *do* result from accidents are partially attributable to improper treatment of the victim by persons on the scene, although the medical profession charitably avoids giving these cases publicity.

First aid is the only contribution which the non-medical person can make toward limiting the severity of particular injuries, in decreasing the chance of fatality, and in limiting the aggravation of non-fatal injuries. The safety director has a real and legitimate interest in the first aid given to accident victims within his plant; this interest springs from his natural desire to limit the severity and cost of industrial injuries.

First-Aid Function and the Medical Department. Where the company employs a full-time medical department, with doctors and nurses in attendance at most hours of the working day, there is no need for an elaborate first-aid system. The sole function of first aid in such an organization is to supplement the medical department's services in the places where and at the hours when the medical department's facilities are not available for the treatment of injuries. Thus, buildings remote from the office of the medical department may be equipped with medical substations or first-aid stations under the supervision of nurses or first aiders, and the main dispensary may be tended by nurses or first aiders during those shifts when few employees are working.

In such organizations, the entire first-aid program is usually directed and administered by the physician in charge of the medical department. The safety department has no administrative control over (nor responsibility for) the application of first aid. This is an ideal condition since it places the injured employee directly or indirectly under the care of a doctor almost immediately after the injury occurs.

Where a full-time medical department exists, it is common policy to have every employee with a minor injury report to a doctor for treatment after receiving first aid. Major injuries are treated by a doctor summoned to the accident scene.

Benefits of First-Aid Training. Even where the services of the medical department are adequate, there are many benefits to be derived from first-aid training of interested employees. Probably the most important of these is the demonstrated fact that first-aid training generally produces an accident-prevention attitude in the persons trained. Some companies have kept special accident statistics on such persons; in almost every instance the frequency and severity of accidents in the trained group have been far below the plant average.

Other common benefits to the company are the avoidance of movement of seriously injured employees, the immediate proper treatment of such dire emergencies as asphyxiation and severe bleeding cases, and favorable publicity resulting when an employee off the job effectively aids an injured person.

Since doctors do not have the time to teach first-aid classes, the actual work of teaching usually falls to the safety department or to the training department, under the direction and guidance of the physician in charge. It has been found desirable to afford every interested employee the opportunity to study first aid at convenient hours on his or her own time. Inducements, such as overtime pay, job recognition, or class attendance on company time, have proven undesirable since they detract from the prime purpose of the instruction and create an erroneous impression in the employee's mind. Similarly, pressure upon employees to enroll in first-aid classes produces disinterested students and renders the instruction ineffective.

These general comments regarding first-aid training, while referring specifically to the situation in the large plant where doctors are available at all times, will apply with even more force to the small plant in which a doctor is present only a portion of the time.

First-Aid Function and the Part-Time Doctor. In small plants it is common practice to engage a doctor on a part-time basis. The doctor is then available at certain hours, one or several days each week, at which time he makes initial examinations of job applicants, makes periodic re-examinations of employees (where required by law or established as a company policy), examines minor-injury cases previously treated by first-aid methods, and performs such other medical functions as may be desired by the plant management. Minor injuries occurring at other times (when the doctor is not at the plant) are either treated by first-aid methods entirely, or are given first-aid care and subsequently sent to the doctor's office for treatment. Major injuries are given first-aid care on the spot, and the doctor or an ambulance is summoned to the scene.

In shops employing only a small number of persons, all required medical work is usually referred to a neighborhood doctor at his office.

In both types of organizations, there is an apparent need for an efficient and comprehensive first-aid organization. This function is generally supervised and administered by the plant safety director, since he is the most interested full-time employee.

As has been pointed out in preceding chapters, the total employment of the many small plants exceeds that of the comparatively few large companies. Consequently, the problem of setting up and directing first-aid functions is one of general interest and grave concern to most safety directors and to plant management as well.

The first-aid problem of the small plant is therefore the principal subject of the remainder of this chapter. To establish a starting point, this problem is approached as it would be by a newly employed safety director entering a going concern. It is assumed that the safety director may consult on matters of policy with the part-time doctor (to whom we shall refer as the plant doctor) but that the doctor himself takes no active part in the direction of the program.

Planning the First-Aid Program. In any progressive concern it is safe to assume that some effort is directed toward assisting the victims of accidents; therefore, in no case would there be an entirely unexplored field for the safety director to exploit. In many cases investigation of the existing facilities will show them to be either inadequate or over-zealous. Either condition represents a dangerous and improper situation and demonstrates a need for correction.

In order to secure the best results from the new first-aid facilities, many items must be planned and executed, the principal ones being:

1. The scope of first-aid treatment that it is desirable to administer must be determined.
2. An evaluation of the previously existing facilities must be made, and they must be adapted to the new scheme. Worthwhile personnel, equipment, and practices should be salvaged from the existing set-up and, equally important, the undesirable elements should be removed from the field.
3. The existing worthwhile personnel should be retrained, and new personnel should be selected and trained either to supplement or replace existing personnel.
4. Materials, equipment, and quarters must be provided for the new first-aid system.
5. A plan for the procedure in case of an accident must be established in order to secure rapid treatment of injured persons under the desired first-aid system.
6. The first-aid system should be integrated with the general accident-prevention plan.
7. A method of supervision of first-aid practices by the safety director must be established and maintained.

Scope of First-Aid Treatment. The term first aid means the temporary and immediate assistance and comfort which trained laymen can properly give an injured person while awaiting the arrival of a doctor or before and during transportation of the injured person to a doctor. Within this definition there is wide meaning, dependent primarily on whether a doctor can be summoned to the scene. In any case, the first aider should supervise the treatment of the injured person while awaiting the doctor or while in transportation.

In an industrial plant, the plant doctor or an ambulance physician can be summoned to the scene of an accident in a relatively short time, usually less than thirty minutes, and rarely longer than one hour. Since medical help is so close and so available, the scope of plant first aid in the treatment of major injuries should be limited to those things which must be done immediately in order that the injury will not be aggravated during that wait of thirty to sixty minutes. Treatment beyond the limits thus indicated may cause extension of the injury or may complicate the administering of proper medical treatment by the doctor upon his arrival.

In the treatment of seriously injured victims of plant accidents, the first aider should summon a doctor and perform whichever of the following treatments may be indicated by the nature of the injury. 1. Resuscitate asphyxiated (non-breathing) persons, using the prone pressure or some other recognized method of artificial respiration. 2. Control severe bleeding if present. 3. Treat nervous shock (by warmth and position only). 4. Wash chemical burns and apply a proper antidote. 5. Apply approved ointment for heat burns. 6. Apply an antiseptic and sterile cover or dressing on open wounds; antiseptics should not be applied on abdominal injuries. 7. Apply approved ointment and patches for eye injuries. In some industrial plants it may be necessary to add certain treatments to the list for specific injuries to which workmen are exposed. Generally, however, this list will be found to be reasonably complete.

Immediate treatment of serious injuries is vital; even a few minutes' delay in commencing resuscitation or in controlling bleeding may cause the death of the victim before the doctor's arrival. Neglect of any of the other treatments mentioned, though not necessarily fatal, will cause the victim's condition to deteriorate seriously during the waiting period. Thus, in administering any of these treatments, the first aider can materially reduce the extent of the final damage to the victim's body and, in some cases, might even be responsible for saving the victim's life. However, the plant first aider should not be permitted to give any treatment that may aggravate an injury or hamper or delay the doctor's treatment of the case.

The first-aid policy of a company should be carefully formulated at its inception and the limits of its operation should be established by executive order. Training courses in first aid are designed to cover all types of conditions, including the treatment of injuries sustained in mines, in camping, or in other places remote from medical aid. Many of the first-aid treatments prescribed in such courses are obviously unjustified in a plant, and the first aider must therefore be specifically instructed as to the proper limitations of his activities and the reasons for those limitations.

Treatment of Minor Injuries. Authorities differ regarding the question of treatment of minor injuries. Many (probably most) small plants follow the practice of having the first aider treat such injuries; the plant doctor examines the persons on his next scheduled visit and prescribes further treatment if required. The minority of plants have every injury victim report to a doctor for treatment after receiving first aid. The safer plan is, of course, the latter, but economic considerations usually dictate that the former be used.

Where medical treatment of minor injuries is deferred, the first aider must be taught to recognize the early signs of infection or other complications that may arise in minor injuries, and he must be specifically instructed as to where the boundary exists between minor and major injuries so that he does not overstep his own limitations. In all such cases, the definition of minor and major injuries should be supplied by the plant doctor; caution in suspecting the most serious possible injury should be emphasized as part of the first aider's training.

Evaluation of the Previously Existing First-Aid Facilities. Occasionally the safety director will find a conscientious and capable first-aid organization in operation at a plant. The task of converting such an organization to a new program is simple. It is necessary merely to inform the first aiders of the limitations fixed on their activities by executive order and by their own moral responsibility, provide the required equipment, arrange for training of additional help, if needed, and finally establish the first aiders' authority by an executive order directing employees to report their injuries to this group. This, however, is the exceptional case. Generally one of these conditions exists. 1. The first-aid function has fallen to the lot of some foreman or other supervisor who has many other things to do after an accident and who consequently neglects first aid. 2. Some sincere, but misguided, person has acquired the first-aid functions and, having fixed ideas of his own ability and scope, abuses his position.

In the former case the foreman, or supervisor, will probably welcome a chance to give up the responsibility, and no personnel problem need be anticipated. But in the latter case, the original first aider will probably be jealous of his assumed authority and will resent the intrusion of a new first aider. In the interest of all parties, such a situation requires tactful handling.

In any case the major objectives in setting up the system of first-aid treatment are the following.

1. Arrange to have at least one thoroughly trained and competent first aider on the premises during all regular working hours.
2. At the outset, establish an order of authority so that, if two first aiders are on the scene of an accident, one will automatically assume command.
3. The first aiders should, and in most cases do, have other functions to perform when not acting in that capacity. Preferably these functions should be such that they can be readily suspended during the period immediately following an accident. Since foremen and maintenance men have the responsibility of reestablishing normal operations after an accident, they should not be given this added after-accident job if it can be avoided. On the other hand, stockmen, timekeepers, and office personnel can readily suspend their activities and be available for use as first aiders.
4. The outstanding characteristics necessary in a good first aider are caution in estimating the extent of injury, a real interest in first aid, competence, and a sound realization of limitations. Plant first aiders should be selected and rated on the basis of these qualifications rather than on their position, seniority, or any other non-relevant circumstances.

These considerations will assist the plant doctor and safety director in deciding what changes in first-aid personnel are necessary or advisable in instituting the new system. They may also suggest tangible means of removing first aiders who are undesirable in that capacity.

First-Aid Training. It is usually necessary at the start of a first-aid program to retrain those first aiders who are to continue in the function and to train new men to supplement them. All plant first aiders should, as a minimum requirement, be graduates of the American Red Cross standard and advanced courses in first aid or of the United States Bureau of Mines training course. Preferably they should be qualified instructors of first aid, since, in first aid as in any other subject, one learns most by teaching. If previously trained persons are to be used as plant first aiders, they should be put through refresher courses unless their original training has been very recent.

It is impossible before training to foresee which members of a group will become truly competent, and it can be assumed that in most cases only a small part of the group will qualify. For this reason it is best to start training a relatively large number of persons, at least five times as many as will be required for plant first-aid purposes. Since, as previously noted, there are definite advantages to the company in training employees in first aid, the instruction will not be wasted on those persons subsequently not used.

All first-aid courses give instruction in many treatments not generally permitted to be used by the plant first aider. With reference to first-aid instruction for industrial establishments, the American Red Cross recognizes this fact and permits instructors to deviate from the normal course, where such deviations are requested by the plant doctor. For instance, splinting of fractures is included in every course of instruction, but almost all plants exclude it as a first-aid treatment except in dire emergency. This teaching of exceptions can be done if one plant, or several plants, can enroll enough candidates to make up a complete class. If this condition does not exist, the plant personnel will probably take first-aid training with some outside group; each plant employee in the class should be specifically warned by the plant doctor about the limitations in treatment by first aiders of injuries within the plant.

It becomes apparent that the safety director, and his assistants if any, should be capable first aiders. This is not always possible since they may lack the necessary physical qualifications. As a minimum, all such personnel should be thoroughly trained in first-aid methods so that they can at least qualify as competent critics of the technique of the plant first aiders.

The successful trainees, who possess the necessary qualifications of competence, caution, and realization of their limitations, should be considered as to availability as well as to first-aid technique. The choice of plant first aiders and the order of command among them would depend upon this consideration.

Material and Equipment. First aid requires the use of specific supplies, the nature of which depends upon the nature of the injuries that the first aider might have to treat. All materials should be considered on the basis of effectiveness and lack of interference with subsequent treatment by the plant doctor. The plant doctor should therefore have a controlling voice in the preparation of specifications for first-aid supplies. In most cases first-aid materials in unit packages (each designed for a single use) are preferable to those purchased in bulk because of the greater degree of retained cleanliness.

When the first-aid materials to be provided have been determined, a problem exists in so placing these materials that they will be readily accessible in case of accident. In most accidents, the injury is not severe and the injured person can walk or be assisted to a central location for first-aid treatment. However, in the occasional severe injury, the victim cannot be moved until the arrival of the doctor, and preparation must be made for treatment at the scene of the accident. Thus two distinct problems are presented, each of which requires an individual answer.

First-Aid Room. The usual answer to the treatment of minor-injury cases is a first-aid room. A first-aid room is a separate room specially equipped to facilitate first-aid treatment and is not permitted to be used for any other purpose. It need not be large, but it should be carefully designed for the purposes for which it is to be used, which are: first-aid treatment of walking cases; use by the plant doctor, while at the plant, for examinations and for repeat visits of minor injuries; in the event of a severe injury the doctor may wish, upon his arrival at the scene, to remove the accident victim to the first-aid room for preliminary surgical treatment.

In order to serve these purposes, the first-aid room should be isolated from normal plant activities so that it can always be maintained in a clean condition. It should provide privacy for first-aid or medical treatment, make the injured comfortable and avoid the danger, otherwise present, of bystanders being upset and shocked from viewing the injury and its treatment. An examining table should be provided for the doctor to use as an emergency operating table. A folding stretcher is a required piece of equipment for any first-aid room. Washing facilities must of course be provided, as well as a writing table and chairs. For use in examinations, the first-aid room should be partitioned into at least two distinct areas.

The first-aid room should contain a full stock of first-aid supplies and such other materials as may be desirable for use by the doctor. Splint packages marked " For Physician's Use Only " should be available so that a doctor called to the scene will be able to affix splints readily. In some cases it may be desirable to provide a full-length body splint, especially in plants where falls from high places may be experienced. Where asphyxia is an apparent hazard, an inhalator for the supplemental treatment of resuscitation cases should be provided.

Since stretchers and other equipment provided for the treatment of serious injuries are infrequently used, they must be inspected regularly. Canvas and leather parts of this equipment should be examined for rotting and cracking. Stretchers or cots normally stored in a folded condition should be opened and examined with canvas under tension.

The washing facilities should provide for the first aider's cleaning of his own hands or for his washing of hands, arms, or other parts of the accident victim's body. A washstand, with a mixing tap brought out through a high goose-neck to a spray head, is the best answer to this need. Such a device permits washing of hands, head, or arms under running water and out of contact with the sink. Preferably the tap should be controlled by foot levers. Soap dispensers for ordinary soap and for antiseptic green soap are required. An adequate supply of towels, either cloth or paper, should be available.

First-Aid Area. In many plants the first-aid room is omitted and a first-aid area is set up in an office. Such an area is generally unsatisfactory because normal functions of the office tend to overflow into it and take up the available room, in some cases concealing the first-aid equipment. In such instances the first-aid materials are often put in inaccessible hidden places and are therefore not readily available for the treatment of injuries. A first-aid area is obviously unfitted for the treatment of a major injury, since, in such cases, the mess accompanying the treatment may render the office space uninhabitable for days after the injury.

First Aid at the Scene of an Accident. For prompt first aid to persons suffering major injuries, equipment must be easily accessible to the scene of the accident. This can be accomplished either by placing first-aid kits at various points around the plant or by forming flying squads that consist of one or two first aiders with accident kits, such squads being subject to call to any part of the plant in which an accident may occur. The choice between these alternatives will depend upon the first-aid organization setup and the general layout of the plant.

The idea of a flying squad is limited to plants that employ full-time first aiders who are normally stationed in a first-aid room and are thus immediately available on call. This arrangement is quite common in plants covering a large floor area, as in assembly plants. In some cases the first aiders are provided with scooters or other means of rapid travel through the plant.

Where the first aider is regularly employed in another capacity, the placing of first-aid kits around the plant is the better plan. With this arrangement, the first aider can proceed directly to the scene of an accident, picking up a kit on the way and thus avoiding the need of first going to the first-aid room. A disadvantage of this plan arises from the pilfering of first-aid materials from kits for home use. This seems to be a fault in almost all plants. Its particular danger arises from the fact that, when a serious injury occurs, the kit may be found deficient in the vitally required materials. This danger can be greatly reduced, and in some cases eliminated completely, by putting paper seals on the kits in such a way that the seals must be destroyed in opening the kit; the broken seals can be detected by visual inspection in passing.

Cooperative First-Aid Room Serving Several Plants. Where several small plants, each one unable to support its own first-aid room, are located in one building, it is often possible for them to band together and equip a room and hire a first aider or nurse for the common use of all. This facility is usually supplemented by first-aid kits maintained in each of the several plants.

Procedure in Case of Accident. First-aid facilities having been set up, it is necessary that the employees be instructed to report all injuries for first-aid treatment. This is most effectively done by an executive order outlining the procedure to be followed in case of an accident. The order should direct all accident victims (no matter how slightly injured) to report for treatment to the first aider and should specify that, in the event of serious injury, the victim should not be moved, but the first aider should be called to the scene. It should also specify that, if the first aider is not available, a public ambulance should be called.

Even in plants where excellent first-aid facilities are installed, it is often found almost impossible to prevent mistreatment or abuse of the accident victim in the interval before the first aider arrives at the scene. Therefore, it should be definitely emphasized that victims of major injuries should not be moved by unauthorized persons. In most plants the first aider is required to fill out accident-report forms. They should be supplemented by reports prepared by the foreman.

First Aider and His Relation to Accident Prevention. First-aid training and the administration of first-aid treatment produce in almost every individual a safety consciousness that can be made extremely useful to the safety director. The first aider, in preparing his reports, can often obtain many pertinent facts that may be lost in an investigation occurring several days after the accident. The first aider can be trained to detect preventable causes of injury and to call immediately to the attention of the safety director any accident (no matter how slight the injury) in which the potentialities of a serious injury exist.

Conclusions. In large companies, first aid is simply a supplement to the activities of the medical department and is operated under the direct supervision of the physician in charge.

In small companies, medical attention is not usually available and the first-aid function consequently assumes greater importance. In the absence of a full-time doctor, the safety director is usually charged with the responsibility for establishing and supervising the first-aid program. In such cases, especially, first aid is a control in limiting the severity of injuries and is thus definitely related to accident prevention. The first-aid program must be carefully watched and supervised to prevent abuse.

CHAPTER XXII

Artificial Respiration

Normal Respiration. Normal respiration in the human body is a continuous process of ventilation. The purposes of respiration are, on inhalation, to supply oxygen that combines with food products to generate heat and muscular energy and, on exhalation, to remove carbon dioxide (the waste gas of that combination) from the body.

Respiration is caused by a muscular action that alternately expands and contracts the chest. Expansion causes the pressure within the chest to decrease below outside air pressure (causing fresh air to enter the lungs). Contraction causes the pressure within the chest to increase above outside air pressure (causing used air to leave the lungs). The muscular action may be voluntary or consciously controlled, but at most times it is involuntary or automatic, and not requiring conscious control.

Two sets of muscles can produce respiration, either or both of which may be used. One set is capable of moving the ribs, which form the walls of the chest cavity. The other set is capable of moving the diaphragm, which is the floor of the chest cavity. They may work independently or in unison. When air is drawn into the chest, the blood picks up oxygen from it and discharges carbon dioxide into it. The reason for this interchange lies in the chemical fact that blood has a far greater affinity (preference) for oxygen than for carbon dioxide.

Injuries That Cause Stoppage of Respiration. There are many types of injuries that may cause respiration to cease; the following are those most commonly encountered.

1. An electric shock, under certain conditions, will cause the nerves that control the chest and diaphragm muscles to cease functioning, which in turn causes those muscles to become paralyzed. When this paralysis occurs it is temporary, but, if breathing is not maintained by artificial respiration, death will usually occur from lack of air change before the paralysis passes.

2. Absorption, by the blood, of a gas for which the blood has a greater affinity than it has for oxygen decreases the capacity of the blood to carry oxygen. Thus blood has an affinity for

carbon monoxide which is several hundred times as great as its affinity for oxygen. In an atmosphere containing a very small part of carbon monoxide (5 parts in 10,000), the blood will absorb the carbon monoxide in each inhalation and will not throw it off on exhalation. In such an atmosphere, over the course of about half an hour, the blood will progressively absorb so much carbon monoxide that it will be unable to carry enough oxygen to sustain consciousness, and the person becomes unconscious. Longer exposure will increase the absorption until there is not enough oxygen in the blood to sustain breathing, and breathing ceases. Death will occur in a few minutes thereafter unless artificial respiration is commenced.

3. Suffocation, such as occurs in drowning, strangulation, or smothering is a condition in which the air passage to the lungs is blocked. In such cases the body is cut off from air. If this condition exists for several minutes, the oxygen in the blood is used up so completely that there is not enough left to sustain the breathing effort after the supply of air is restored. Here also death follows swiftly unless artificial respiration is applied promptly.

Treatment of Stoppage of Breathing. In every case of stoppage of breathing (asphyxiation) resulting from these and similar causes, there is a considerable chance of recovery if artificial respiration is applied promptly. It must be remembered that death will occur rapidly if the breathing is allowed to remain interrupted; the chance of survival is said to decrease by about 10 per cent for every minute that the application of artificial respiration is delayed. Obviously, it is impossible to expect that a rescue squad will be on the scene in sufficiently short time after asphyxiation occurs so that treatment can be delayed until their arrival. The person who first finds the victim is the one who, if he knows the method, has the best opportunity of reviving the victim. Therefore, in any plant in which asphyxiation hazards are present, it is vitally important that a sufficient number of persons be familiar with resuscitation so that at least one of them will be on the scene in the event of asphyxiation.

Theory of Artificial Respiration. Below the chest cavity, and separated from it by the diaphragm, is the abdominal cavity in which are located the intestines and various other organs. If pressure is placed on the abdominal cavity, the intestinal mass can be forced up against the diaphragm, causing it to decrease chest volume and consequently causing an exhalation. When pressure is released, the diaphragm returns to normal position, increases chest volume, and causes inhalation. This cycle is the basis of the Schafer method.

In the Sylvester method, respiration is caused by the expansion of the chest by manipulation of the arms, and contraction of the chest by direct pressure on the chest wall.

Schafer Method (Prone Pressure). In this method the body is placed face down on a hard surface (the hard surface confining the abdomen and forcing diaphragm action) with the face supported on the back of one hand, and the other arm stretched out and up from the body. The operator kneels, straddling one or both legs of the victim, and rhythmically applies and removes pressure. A count of five is employed, each count being one second. The operating cycle is as follows:

1. Hands in position, the operator squatting all the way back, at the count of one, starts moving forward.
2. By this count, the operator should have reached the position of shoulders above hands, upper legs straight up and down; he should immediately reverse and start to move toward the position of rest (squatted on heels).
3. The operator should reach the rest position at this point and should remove his hands, sit back, and relax.
4. Rest.
5. Rest.

The two-legs straddle is preferred to the one-leg straddle because it decreases the rate of loss of bodily heat and permits wrapping of the victim in a blanket. A further preference exists because of the greater operator comfort in the two-leg straddle. A small operator on a large victim may of necessity do a one-leg straddle.

The operator's hands must be just above the hip bones, bearing on the soft flesh of the small of the back and on the lowest ribs. Heels of the hands must be about four inches apart to avoid injury to the victim's spine. Fingers must be pointed down along the side of the body, and thumbs must be kept close against the sides of the hands to avoid gouging.

If an asphyxiation victim is on his side or otherwise close to a face-down position, the body may be arranged in proper position with little trouble. If the victim is on his back, the body may be turned to a face-down position by the following technique:

(a) grasp both forearms, right forearm in right hand, left forearm in left hand; *(b)* draw the victim's arms above the head; and *(c)* dropping one arm but holding the other firmly, step quickly toward the side on which the arm has been dropped, pulling the other arm across the body. With this procedure, the body will roll over with little effort on the part of the rescuer.

The essentials of the Schafer prone pressure method are then: victim face downward on a hard surface, head bridged on hand and other arm up and out, prompt application of method, operator's hands in proper position to avoid injury to victim, rhythmic and uniform count.

While applying artificial respiration, it is advisable to have a bystander call a doctor and rescue crew so that other helpful treatments may be instituted.

Preservation of Warmth. When there is no breathing, there can be very little heat generated in the victim's body. The body heat must be conserved to give the victim the best chance of recovery. The victim's body should be wrapped in a blanket if one is available. This must be done while resuscitation is continued; wrapping must never delay or interfere with resuscitation. Wrapping can be done by a single assistant during resuscitation by the following method.

1. The operator starts counting aloud his cycle of resuscitation.
2. The assistant rolls the blanket two-thirds of its width.
3. The assistant places this roll close along one side of the body.
4. The operator unstraddles, kneels with both knees together at the far side of the victim's body.
5. The assistant places one hand under the near hip of the victim, grasping the hip joint and groin firmly.
6. During the operator's rest period, the assistant half-rolls the victim away from him and, with his free hand, unrolls the blanket about half way under the victim. The assistant *must* return the victim's body to a prone position before the next count of one, even if the blanket-unrolling operation has not been completed; he may use two or more cycles for it if necessary.
7. The assistant places his hand around the far hip of the victim, again grasping the hip joint and groin firmly. During the operator's rest period, he half-rolls the victim's body toward him and unrolls the blanket out to the far side. Again the victim's body *must be* returned by the count of one.
8. The ends of the blanket are brought over the victim's back.

9. The operator returns to straddle and continues the regular operation.

10. The assistant rearranges the victim's arms and head.

In the blanket roll, no interruption of the rhythm of artificial respiration can be permitted. If in operation 6 (above) the assistant has not been able to complete unrolling the blanket half way beneath the body of the victim before the completion cycle (that is by the cycle count of five), he must nevertheless restore the victim's body to the proper position for the application of pressure at the next count of one. Similarly, on operation 7, the body must be returned to position for the next pressure application even if the operation of unrolling the blanket has not been completed. Each of these operations (6 and 7) may require two or more resuscitation cycles for completion, especially if the victim is large.

Warning against the Application of Heat in Resuscitation Cases. It was previously considered that artificial heat should be supplied to the body during resuscitation. Recent study by Dr. George E. Burch, of Tulane University, and Dr. G. K. Wakim and Dr. W. D. Gatch, of Indiana University, indicates that artificial heat is actually damaging to the patient. In cases of extreme nervous shock, such as is present in all resuscitation cases and in many less serious injuries, the blood vessels deep inside the body are relaxed and expanded, while those close to the skin are constricted. Thus a natural balance is created. The application of heat destroys this balance by causing dilation of the blood vessels close to the skin and thus causing more blood to flow into them.

The direct application of heat has two other damaging effects noted by these doctors. Heat hastens chemical reaction in the body, thus consuming more of the already deficient oxygen for functions that are not of prime importance. Heat also increases perspiration, adding to the fluid loss which is a serious condition already present in shock.

Inhalator. The inhalator is a device designed to supply to an asphyxiated person an atmosphere rich in oxygen and containing a small amount of carbon dioxide to stimulate breathing. It is a valuable aid in increasing the effectiveness of resuscitation, but does not replace it. Resuscitation must be continued along with the application of the inhalator.

Inhalators are generally kept on hand by utilities, police emergency groups, and fire departments and are available on call. One should be called for in every resuscitation effort; a bystander should be directed to call for this equipment.

Drinker Respirator. The Drinker Respirator, or iron lung, is a safe machine which produces artificial respiration by rhythmically alternating slightly positive and slightly negative air pressure over the outer surfaces of the body while the head of the patient is exposed to normal air. Its action is gentle but extremely effective. The Drinker Respirator has been successfully used in hospitals in the treatment of chest paralysis resulting from disease. However, it is extremely heavy and cumbersome and, therefore, is not available as a means of resuscitation of accident victims at the scene of an accident.

Other Mechanical Devices Designed for Resuscitation. A number of other mechanical devices have been designed for the resuscitation of asphyxiated persons. None of these have proven successful, and some are distinctly damaging. In the latter category can be included the Pulmotor, which was discredited about thirty years ago, and similar instruments which, by alternately blowing air or oxygen into the throat and sucking it out, attempt to induce breathing.

Sylvester Method. In this method the victim is placed on his back, the tongue is drawn forward and held there with forceps, and the arms are first stretched above the head and then bent down and pressed against the lower chest and upper abdomen. The same rhythm is maintained: twelve cycles per minute. This method is exhausting for the operator and is therefore rarely used. It is advocated where the victim is a pregnant woman.

Warning: Injuries That May Be Inflicted through Improper Artificial Respiration Technique. In every case requiring artificial respiration the victim is completely relaxed and is therefore especially subject to damage at joints of the body skeleton if improperly handled. In the artificial respiration procedure there are several steps in which the danger of this type of injury, or of other serious injuries, exists. Specific types of injury that can be inflicted by improper technique are listed below.

1. If the victim is turned over by pulling at the hands or wrists, one wrist can be readily dislocated or sprained. This can be avoided by grasping the forearms of the victim in turning him into proper position.
2. The spinal column can be seriously damaged if struck by

the hands, or even by simple pressure. The wrists of the operator should therefore be kept about four inches apart to prevent pressure or a blow on the spine.

3. Impact on the soft flesh at the back of the abdomen can produce painful and severe damage to the muscles or to internal organs. This can be avoided by bringing pressure on smoothly, starting with the operator's hands in place before moving from the rest position.

4. The thumbs of the operator, if allowed to stand out from the hands, will gouge the back of the victim. During artificial respiration the operator's thumbs should be held parallel to his fingers and touching his forefingers.

5. Moving the hands about, especially while pressure is being applied, will bruise the skin of the victim's back and, in some cases, will actually wear the skin completely away. This condition is most likely to become severe in drowning cases where sand may be present. Properly placing the hands, and keeping them in one position on the victim's back, will prevent this type of injury.

Obviously, any of the above injuries is minor as compared to death resulting from lack of resuscitation. However, each of these is unnecessary and the faults that produce them can easily be eradicated in resuscitation practice.

Rescue Before Resuscitation. In most cases where resuscitation is necessary, the victim must first be removed from the source of his injury. The rescuer must protect himself from the same hazard.

1. In electric shock, using a piece of dry, unpainted wood, push the victim out of contact with the electrical conductor; or, using dry clothing or belting, loop the victim's body and draw it out of contact. Do not move the electrical conductor (if a loose wire) as it may be caused to touch a good ground and whip about. These methods are safe on low-voltage and intermediate-voltage contacts. On high-voltage contacts properly insulated devices are required.

2. In gas poisoning, ventilate the area and hold your breath. Entering, prop the door wide open. Break the glass out of any windows along the way with any convenient object. Drag the victim to pure air. If necessary to breathe before rescue is completed, leave the victim, return to pure air at the nearest broken window, breathe, return, and complete the rescue.

3. In cases of drowning, do not attempt to perform a rescue (unless you know how) if there is a qualified person to do it. In any case do not get in the way of a lifeguard or another trained rescuer. If persons regularly spend time at a bathing place and if they swim, they should learn the proper rescue technique. Any person who swims can, with very little instruction, learn how to support another in water, keeping the exhausted or cramped swimmer afloat. This much at least should be learned by every swimmer. Wherever possible, attempt rescue by throwing rope to the drowning person or by reaching an oar or branch to him, the rescuer meanwhile staying in a safe location. Nonswimmers should confine their rescue attempts to the latter methods.

CHAPTER XXIII

Psychology and Safety

Several psychological factors have been found to be definitely related to industrial accidents, but accident-prevention authorities are not in complete accord as to which factors apply in specific types of cases. However, it is rather generally agreed that failures of men do have psychological causes as the basic underlying factor, and the volume of these cases in proportion to the total number of accidents is great. This is probably due to the fact that many physical factors have been corrected but relatively few attempts have been made to control the purely psychological causes of accidents.

Some authorities are unsympathetic to utilizing psychology in accident prevention; others are under the impression that psychology is associated with the practice of placing blame, which actually is directly opposed to psychological accident prevention. These authorities resort to psychology only in rare cases and only when all else has failed, or they attempt to use psychology alone without any other mode of accident prevention.

A more logical approach to the problem is to use psychology on an equal basis with engineering revision, employee education, and training (wherever the need for it is indicated) and to use it along with other preventive devices.

There are several types of accidents which by their very nature invite psychological prevention. Foremost among these are accidents arising out of instability of employment, fear of layoff, prolonged labor disputes, and other conditions which encourage fear or hate hysteria and result in low plant morale. Correction in these cases is within the control of management. Prompt adoption of a clear-cut and fair executive policy will in most cases stop the building up of such conditions before they can attain any sizable proportions. The problem is to spot such conditions in their incipience and to bring them forcibly to the attention of management. Obviously this is primarily a problem in labor relations; the resulting accidents and their prevention are secondary. However, the safety director, through his inspectors, other wide contacts, and accident record may be able to discover the condition early enough to make its elimination possible.

Other accidents that are capable of psychological prevention are results of temporary conditions of "accident-proneness" arising from personal crises. Effective work here demands the greatest tact and kindness; usually it is advisable to shift temporarily persons thought to be in this condition to relatively safe work rather than attempt to discover the reason by investigation. After the crisis is past (as shown by the person's condition and reactions), he can be restored to normal duties.

In a general sense, psychological accident prevention would attempt to eliminate the fault in the person, which is at the beginning of the accident sequence. Usually a complete study of the background would be necessary before corrective measures could be undertaken. Practical considerations prevent psychological accident prevention in most accident cases. This is due primarily to the safety man's lack of personal knowledge of the average employee and secondarily to a lack of qualifying training.

The competent foreman is in a better position than the safety director or others to apply psychology in individual cases because of his close association with men. It is not necessary to know the technical terms and names since inherent psychologic knowledge is a characteristic of leadership. All foremen must have some of these qualities.

New Employees. Psychological tests have proven helpful in selecting new employees best adapted to a particular job. This, plus a thorough medical examination, provides information that enables the employment manager to utilize his job specification intelligently. Some jobs require keen eyesight, others manual strength, others good color sense, and still others extreme emotional stability. The last mentioned of these is at least as important as the others, and it (and similar characteristics) can be determined only by psychological testing. However, since such tests are in no sense mathematically accurate, complete dependence cannot be placed on them.

Test results are occasionally unfair because of the extreme and unusual nervousness of the applicant for a position. Another objection is the time interval required for such tests. A more practical plan, often followed at the present time, is to complete the regular employment schedule, deferring the test to a more appropriate time. This will permit the transferring of maladjusted or improperly placed employees into work more suitable for them.

ACCIDENT-PRONE EMPLOYEES

Employees who have a relatively high accident rate caused by peculiar personal factors may be considered accident prone. Fatigue has been found to be a frequent cause in accident proneness. Some of the other psychological factors related to accident proneness are defective vision, employee's age, length of service, emotional factors, and mental instability. Poor working conditions and lack of job satisfaction are also important factors.

FATIGUE

There are at least three different conceptions of fatigue, from the accident-prevention standpoint. These are: psychological fatigue, physiological fatigue, and industrial fatigue.

Psychological Fatigue. Psychological fatigue may be defined as boredom and tiredness from uninteresting repetitive tasks. The person develops a feeling of lassitude, desires to do something else, and feels he needs a change. The reason is not always apparent.

Physiological Fatigue. Physiological fatigue may be defined as consumption of energy in the execution of a task. It is primarily a matter of chemical changes in the muscles. This is not always accompanied by a feeling of exhaustion or by a reduction of the immediate amount of work a person is able to do.

Industrial Fatigue. The industrial supervisor and foreman may not be interested in either psychological fatigue or physiological fatigue, but he should be interested in employee efficiency. It is the purpose of this discussion to describe in detail the various factors involved in what is commonly known as industrial fatigue. These may be defined as those conditions which result in decreased employee production or lack of personal efficiency.

Improper illumination is an important factor in industrial fatigue. Illumination should be sufficient to insure a satisfactory level of visual acuity. This will be found to be about forty foot-candles in most industrial applications. Illumination is particularly important where employees are engaged in fine work requiring a high degree of accuracy. In most cases it will be found that the increased expense necessary to attain good illumination will be more than offset by the increase in rate of production. (Refer to Chapter XI, " Illumination.")

The employee's visual adaptability to the job is another important factor. Employees should be selected on the basis of adequate vision, and those having any impairment should be provided with correction through special occupational spectacles or other visual aids.

The control of temperature and ventilation of the working place is receiving more attention both because of its effect on the employees themselves and because of its effect upon the material in process. Unfavorable humidity is probably the condition most difficult to control. Such control is expensive to install and costly to operate and in general is installed only where required for the process. Since labor cost is so large a part of total cost of manufacture, it is probable that in most industries the installation would be justified by increased efficiency. This development is largely for the future.

Noise is also a frequent cause of industrial fatigue, but its control is difficult, and its elimination is an involved task. However, in this case there is no operating cost; the only charge is for installation. Where sound-proofing or individual booths are installed, the quality of work invariably improves. Fatigue is lessened in direct proportion to the reduction in noise.

Food. Food that is inadequate either in quality or quantity results in a person losing the ability to withstand physical exertion. To meet this consideration, some companies have found it desirable to provide free meals for their employees, others to provide cafeterias where nutritious meals may be served at reasonable cost. Experience has rather definitely proven that an adequate supply of good food will result in greater output and more efficient work. A company cafeteria that distributes good food is economic even though most such cafeterias lose money.

Salt tablets have been generally accepted by industry for all employees during the hot weather and also for employees working in hot locations.

Hours of Work. Now that the forty and forty-eight hour weeks have become standard and many plants are operating on a twenty-four hour basis, the problem of how to allocate the working hours to the individual in order to attain greatest efficiency and lack of absenteeism is increasingly important. Various plans have been tried, one of the most successful being four twelve-hour days with three days off for the employees. This may reduce absenteeism, but it does not produce high individual efficiency. Six eight-hour days with two rest periods, in addition to the lunch hour, is a more satisfactory arrangement.

Studies have shown that constant night work results in decreased output, probably as the result of fatigue. Present-day efforts to provide a more normal social life for night workers offer a reasonable chance of improving this situation. There is no reason why parties and amusements cannot be gauged to meet the work schedule. It is felt that this will reduce night-work fatigue. Another, and older, plan is to rotate the shifts, a plan which presents the frequent need for personal readjustment. In this case the short swing should be avoided.

Except for periods of short duration during which a longer work week would be desirable, the greatest production is achieved when the work week is limited to forty-eight hours. It has been demonstrated that a work week exceeding forty-eight hours reduces personal efficiency so sharply that the total achievement is not much more than for the work week of forty-eight hours, in some cases below that obtained in the normal forty-eight hours.

Many investigations have been made regarding the advantages of rest pauses. In every case such recesses have been found to be well worth while from the point of view of employee comfort, increased efficiency, and overall greater rate of production. Normally a ten-minute pause in the mid-morning and mid-afternoon is adequate. Employees working on piece work may object to such arrangements. If the real purpose is adequately explained to them, it will be easy to prove that their total earnings will be greater with the recess than without it.

Job Analysis and Engineering Revision. Fatigue can be reduced by eliminating all unnecessary motions and utilizing mechanical equipment for heavy work where possible. Improper posture is a fatigue factor. The height of benches and chairs should be carefully checked, particularly with new women employees. Improper guards on machines, or guards with members perpendicular to the movement of the member guarded, will cause eye fatigue. Engineering revision is indicated in such cases.

Eye strain may be the result of poor illumination or optical defects of individuals. Engineering revision will take care of the illumination problem, but an eye examination by the medical department and proper prescription lenses take care of the eye defects.

General. Fatigue is the cause of most accidents classified as the result of inattention or carelessness. Fatigue contributes to many accidents that apparently are caused by willful violation of the rules. Fatigue predisposes persons to infectious illnesses ranging from the common cold to pneumonia or tuberculosis. Fatigue causes errors that result in waste, spoilage, and damage to equipment. Fatigue aggravates chronic conditions, such as heart ailments and ulcers. Because of all these various avenues of attack, fatigue is considered as the root of many industrial absentee problems, including absences due to legitimate illnesses.

The accident-prevention program should include a thorough investigation of all possible sources of fatigue, and a determined effort should be made to eliminate or compensate for these sources. Fatigue control will improve work efficiency in addition to cutting down absenteeism for all sources.

Mutual Confidence as a Psychological Factor in Accident Prevention. Although it is not normally considered in this way, the greatest application of psychology to the total problem of accident prevention is the creation and maintenance of mutual confidence between the accident-prevention group and the production group. This can be brought about only by continuous and well-directed effort on the part of the accident-prevention group. Once established, this confidence provides a channel for the easy transmittal of accident-prevention information from the safety department to the various operating groups. It permits the safety director to act as consultant without prejudice and encourages operating groups to bring their specific problems to him. In a word, it adds the entire working group to the safety inspectional staff.

In order to obtain this result, it is necessary that the safety effort be conducted in a way which will inspire respect. This means a complete avoidance of the spotting or checking techniques; it means open discussion of defects in equipment and processes with the person deemed responsible rather than writing letters or reporting over his head; it means confidential handling of matters reported in confidence; it frequently means that the safety director must subtly plant his own best ideas in the head of someone else in such a way that someone gets the credit while the safety director only gets the accident prevention; and it often means a fight to prevent unjust punishment of an accident victim. In short, it means an abandonment of the paper evidence of great activity and of other devices intended to impress executives in spite of a continued poor accident record, and substitution in their place of a cooperative effort which must produce improvement in the accident record.

CHAPTER XXIV

Standards and Codes

Standards have been developed for the safe construction, operation, and maintenance of many general classifications of plant equipment. These standards are recognized as representing the minimum requirements for good practice with reference to the particular equipment covered. In some cases, the standards are subject to considerable improvement so that many plants exceed their requirements as a matter of good policy. However, many of the standards have been so well-developed that they represent the best possible practice. To exceed them would be wasteful. Some examples are the National Electric Code; the American Society of Mechanical Engineers Boiler Code; and the American Standards Association Safety Code for Ladders, Safety Code for Mechanical Power Transmission, and Safety Code for the Use, Care, and Protection of Abrasive Wheels.

Where different standards cover closely associated equipment, great care is taken to secure uniformity on all points at which they parallel. This is done even where the standards are prepared and promulgated by different organizations to avoid conflict of authority.

The requirements for developing and maintaining a good standard are these.

1. All interests legitimately concerned must be consulted and their views and requirements properly considered in establishing the standard.
2. The standard must include all provisions required by law.
3. Other organizations that issue standards must be consulted on matters of mutual interest to avoid possible conflicts.
4. The standard finally evolved must be clear, definite, and well written.
5. Provision must be made to keep the standard abreast of developments that may come about after its promulgation.

Legal Standards. The various states have enacted laws on the safe construction, maintenance, and use of buildings and plant equipment. In many instances the laws are based upon standards developed by various organizations, including technical societies.

As an example, the National Electric Code is the basis of all building laws with reference to electrical installations and, in many states, has been incorporated in its entirety in the law.

In most cases legal standards are less exacting than the voluntary standards self-applied by industry. The value of property cannot be destroyed by law enactment; therefore legal standards can rarely be made retroactive. This, combined with the difficulty of enacting and revising laws, tends to make legal standards general, rather than specific, in their requirements.

American Standards Association. The American Standards Association has been the leading institution in the formulation of voluntary standards. It had its beginning during the first World War, as the American Engineering Standard Committee. This committee was formed under the sponsorship of the federal government to develop standards which were worthy of national recognition and which could displace the multitude of conflicting regulations and recommendations then in force. The association emerged from this committee under its present name in 1919. Since that date, it has grown until it is now a federation of 46 trade associations, 27 technical societies, 10 major branches of the federal government, and over 2,000 individual companies. It has formulated and promulgated 558 standards. It has proven successful in developing cooperation among the manufacturers and users of industrial equipment and the various state and federal governmental agencies. The interchangeability of such machine parts as bolts, nuts, screws, bearings, valves, and tools is to a large extent the result of its efforts. Similarly, it has brought about a unified set of national standards for electric motors, wires, cables, and supplies, and uniform specifications for iron, steel, and non-ferrous metal products.

Practically every standard prepared by the association has had an indirect benefit in accident prevention. A number of the standards were specifically designed to secure safe design, manufacture, and use of equipment, and equipment parts which are common accident sources. Several outstanding examples of this group were mentioned at the beginning of the chapter.

The association functions through a group of committees, each concerned with the development and continuous revision of a standard or code for a specific type of material or equipment. Approval is based upon the following considerations: (1) the regularity of the procedure followed in developing the proposed standard; (2) the adequacy of the representation on the committee of all interested parties; (3) the degree of unanimity attained by the committee; (4) the legal status of the proposed standard.

The development of safety codes is under the advisory direction of the Safety Codes Correlating Committee. This committee investigates the need for each proposed standard, defines and limits its scope, and correlates the work of committees engaged on the various codes being prepared. It also passes upon the personnel of the technical committees, follows the work of these committees, and acts as a clearing house for safety information.

The functioning of the association in endeavoring to set up a safety standard is briefly as follows. A responsible group makes a formal request based upon an apparent need for standardization as evidenced by accident experience. The association canvasses the industries involved to determine that interest is general. The scope of the proposed standard is then defined and a committee is formed to develop the code.

The development of the elevator safety code is an example of the effort involved in perfecting a standard. The committee, in this case, consisted of representatives of twelve manufacturing concerns, two building management associations, ten governmental agencies, and six independent specialists. The committee required four years to formulate the code. During this period a large number of subcommittees which diligently investigated specific phases of the problem were formed and the National Bureau of Standards performed extensive research that was financed by elevator manufacturers and insurance companies. The code was completed and approved in 1925. The committee continued its work, revising the code in 1931 and again in 1937 as required by developments in the field.

Other Sources of Safety Standards. Many safety standards have been developed by other technical and professional societies. Some of these have been submitted to the American Standards Association for approval; others have not been submitted. Outstanding examples in the latter group are the Power Boiler Code and the Unfired Pressure Vessel Code, both of which were developed by the American Society of Mechanical Engineers and are nationally recognized as authoritative.

Other groups that have developed numerous standards for the safety and health of workers include the Portland Cement Association, the American Society of Heating and Ventilating Engineers, and the Illuminating Engineering Society.

Standards Developed within Plants. The number of safety standards promulgated by all these organizations is still small compared to the vast variety of opportunities for accident; only the most serious and frequent risks have as yet been studied. The period of time required to evolve a standard is quite lengthy so that, under the most favorable conditions, it is necessary that the standard must lag behind the introduction of the new equipment and its associated hazards.

In every plant it is therefore necessary that supplemental standards be developed to cover the accident risks which are not contemplated in the nationally recognized standards. The plant standards are rarely formalized and in many cases are established without the realization that a standard has been set.

Thus, every executive order which requires that certain protective equipment be used on a specific type of risk is, in effect, a plant-wide safety standard. Every job analysis formulated with proper regard to accident prevention is a safety standard even though its scope is narrowed to one operation.

The plant safety director should encourage and actively aid the development of plant standards, since each such standard eliminates the need for a great number of individual discussions and decisions. He should also make use of applicable standards developed in other plants and should attempt to secure their adoption in his own plant. Obviously, he should be familiar with the provisions of all applicable national codes and should cause them to be followed in detail.

National Safety Council. The National Safety Council has published a series of Safe Practices Pamphlets and Health Pamphlets that are available to member companies and their employees. Several of the pamphlets have been incorporated in national standards. The Safe Practices Pamphlets are recognized as authoritative and practical documents dealing with a large variety of subjects. In general, each pamphlet covers all exposures encountered in a specific occupation. As they are concerned primarily with accident prevention, the Safe Practices Pamphlets are not individually as broad in scope as are the American Standards Association Codes, but, for the same reason, the pamphlets can be prepared and promulgated in considerably less time. The Safe Practices Pamphlets are commonly used as the basis for plant safety standards. A standard proposed by the safety director and built upon the general recommendations of the Safe Practices Pamphlets is readily accepted and approved by plant management.

Federal Government Participation in Formulating Standards. Many agencies of the federal government participate actively in the formulating of safety standards. The National Bureau of Standards, the United States Bureau of Mines, the United States Public Health Service, and the United States Department of Labor have been especially active in the field.

The federal government, through many of its branches, actively participates in the work of the American Standards Association, which is the national standardization body. Federal agencies do not pay dues to the association, nor do they dominate its activities; in this work they cooperate on an equal basis with industry.

Since workmen's compensation is an internal matter within each state, the federal government does not issue regulations concerning accident prevention. Through its agencies, it investigates many industrial practices and issues advisory pamphlets containing accurate information with regard to the existence and severity of specific hazards, and protection required to prevent injury. These bulletins are extremely valuable in the absence of national standards concerning the risks.

An outstanding contribution of the federal government has been the United States Bureau of Mines schedule of approval on respiratory protective devices. Approval is based upon effectiveness of protection, sturdiness of the equipment, and general serviceability. There is no restriction against the manufacture or sale of unapproved devices, but approval has been thoroughly demonstrated to be certification that the approved device will satisfactorily perform the functions stated on the approval form.

Occupational Health Standards. The development of standards for the prevention of occupational diseases is relatively new but is rapidly assuming importance. The American Standards Association in 1941 initiated the study of four proposed standards setting safe limits for exposure to toxic dusts and gases. At that time, more than twenty other proposed occupational health standards were being considered by committees. War-emergency conditions have naturally increased the need for the development of such standards.

Retroactive Application of Standards. As far as possible, standards as they are developed should be applied to existing buildings, machinery, and operations. Where the standards would require major structural changes in buildings or equipment or premature replacement of existing machinery, they cannot be applied fully, but it is desirable to investigate the points of deviation and to devise alternative protection. In this way the intent of the standard is followed and its principal purpose is served.

Use of Standards. In practice, every plant should follow the applicable national standards as representing the best practice with consideration for all proper interests. It should also make full use of the advisory services of the federal government and the National Safety Council.

The library of the plant safety director should include a complete list of the American Standards Association standards and codes, copies of each of the American Standards Association Safety Codes and such other codes as refer directly to the work of the plant, a complete set of the National Safety Council Safe Practices Pamphlets and Health Pamphlets, and copies of such of the federal government's advisory pamphlets as are applicable to plant operation. Reference to these sources will provide ready answers to many questions of how to eliminate specific hazards or how best to protect employees from specific exposures and will amply repay their cost and the effort required to obtain them.

CHAPTER XXV

Selection and Purchase of Safety Equipment

The selection and purchase of equipment and devices for personal safety present many problems which are peculiar to this field and which, in their solution, require special qualifications in training, experience, and (especially) in knowledge of the work in which such devices are to be used. There are three legitimate interests involved: the purchasing problem of obtaining the lowest unit price with due reference to quality; the operating problem of obtaining the lowest overall cost, considering unit cost and serviceable life (the latter not always directly dependent upon quality); and the safety problem of providing adequacy of protection. A true solution of these problems requires that they be considered jointly rather than separately. The obvious means of solution lies in cooperation between the legitimately interested parties either through the formation of a purchasing committee or through less formal but effective open discussion of the matter.

As far as the safety aspects of this problem are concerned, a satisfactory solution can be derived by requiring that the purchase of such equipment be done in accordance with specifications set up with the approval of the safety director. Where the item is not one which is frequently purchased, specifications may not be available to govern its purchase; in such cases, the specific approval of the safety director should be required.

In setting up the specifications for any item, full use should be made of the valuable basic work which has been done by such organizations as the American Society for Testing Materials, the American Standards Association, the U. S. Bureau of Mines, and other technical groups that have developed codes covering the construction and testing of many items. Such codes may be incorporated in a set of specifications by inclusion of a simple statement to that effect.

Items in the Purchase of Which the Safety Director Is Interested. The safety director should prepare a list of items purchased by the organization in which he has an accident-prevention interest. This list will probably include all protective devices and rescue equipment as well as many tools and other equipment used in normal production work.

The following table will not prove complete in any particular case but will illustrate the kinds of specialized equipment usually included in such a list.

- Belts
  - Linemen's belts
  - Safety harnesses
  - Window cleaners' belts
- Fire extinguishers
- First-aid materials
- Gloves
  - Acid gloves
  - Electrician's gloves
  - Work gloves
- Goggles, all types
- Inhalators
- Insulated tools
- Ladders
  - Ladder shoes
- Protective clothing
  - Aprons
  - Hard hats
  - Leggings
  - Safety shoes
  - Sleeves
- Respiratory devices
  - Air masks
  - Gas masks
  - Hoods
  - Oxygen breathing equipment
  - Respirators
- Rope
- Safety cans
- Scaffold materials

Testing Procedures. Many of the above-listed items should be tested when purchased to assure that they meet specifications. The conditions of such tests must be definitely prescribed in the specification, and provision must be made to cover rejection upon failure. Certain tests, such as the strength and fatigue tests on rope, destroy the test sample; in such cases a just sampling arrangement, which may be supplemented by the requirement that the entire shipment must pass visual inspection, must be prescribed. Other tests that do not damage the tested object may, if desirable, be applied to every item purchased. Thus electrically insulating gloves are usually required to be tested individually not only on purchase but also at prescribed intervals (every two or four weeks) during their service life in order to insure that any failures that occur will be under test rather than in service.

Where tests are to be made, it may be desirable to set up a laboratory within the organization or to refer the work to an outside laboratory. The choice between these alternatives lies principally in the economic consideration of which is the less expensive; this in turn depends upon the variety and number of such tests.

Approvals in Lieu of Tests. In certain fields it is possible to obtain devices that have been approved by authoritative bodies whose approval is so closely supervised that further testing by the purchaser is unnecessary and wasteful. In such cases it is advisable to require this approval rather than to specify tests. As an illustration, all respiratory devices purchased should bear the approval of the United States Bureau of Mines for use in the atmosphere intended; fire extinguishers, electrical devices, and safety cans for flammable liquids should be approved by some such organization as the Underwriters Laboratories.

Improved Devices. The manufacture of safety equipment is a highly competitive field in which constant improvement is being made in standard devices and new devices are being constantly designed and introduced to meet new conditions. The safety director must keep abreast of developments in this field, by attendance at safety conferences (where they are introduced) and by continuous connection with manufacturers' representatives.

APPENDIX I

*American Standard Method of Compiling Industrial Injury Rates**

1. EXPOSURE

1.1 Average Number of Employees. The average number of employees shall be the daily average number of workers employed, during a stated period, in the industrial unit whose accident experience is under consideration. Each unit shall include all departments, such as production, maintenance, transportation, clerical, office and sales. See R1 and R2.

1.2 Man-Hours of Exposure. The man-hours of exposure shall be the total of man-hours actually worked by all employees. See R3 and R15.

2. INDUSTRIAL INJURIES

2.1 Industrial Injury. Industrial injury shall be the term applied to any injury arising out of and in the course of employment. See R4, R5, R6, R9, R14, and R16.

Six classes of injuries are distinguished as defined in 2.2 to 2.7 inclusive.

2.2 Death. Death shall be the term applied to any injury which involves the loss of the life of the injured.

2.3 Permanent Total Disability. Permanent total disability shall be the term applied to any injury other than death which permanently and totally incapacitates the injured from following any gainful occupation. The loss of, or loss of use of, both hands, or both arms, or both legs, or both feet, or both eyes, or any two thereof, suffered in one accident, shall be considered a permanent total disability.

2.4 Permanent Partial Disability. Permanent partial disability shall be the term applied to any injury other than death or permanent total disability which involves (*a*) the complete loss of any member of the body or part thereof, or (*b*) the permanent impairment of any function of any member of the body or part thereof. See R9.

2.5 Temporary Total Disability. Temporary total disability shall be the term applied to any injury other than death, permanent total disability, or permanent partial disability which in the opinion of the doctor makes it impossible for the injured employee to return to work on the calendar day following the day on which the injury occurred, or on some later day. See R6.

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2.6 Temporary Partial Disability. Temporary partial disability shall be the term applied to any injury other than death, permanent total disability, permanent partial disability, or temporary total disability which in the opinion of the doctor makes it impossible for the injured person to return to his regular job on the calendar day following the day on which the injury occurred, or on some later day. See R6.

2.7 First-Aid Case. First-aid case shall be the term applied to any injury, other than death, permanent total disability, permanent partial disability, temporary total disability, or temporary partial disability, which receives at least first-aid or medical treatment but which in the opinion of the doctor does not make it impossible for the injured person to return to his regular job at or before the start of the next calendar day following the day on which the injury occurred.

3. TIME CHARGES

3.1 Time Charges. The time charge is the measure of disability stated in days, as specified in Sections 3 and 4 of this code.

3.2 Time Charge for Death. Six thousand (6,000) days shall be charged for each death. See Section 4, also R5 and R10.

3.3 Time Charge for Permanent Total Disability. Six thousand (6,000) days shall be charged for each permanent total disability. See Section 4, also R5 and R10.

3.4 Time Charge for Permanent Partial Disability. The time charge for permanent partial disability shall be as follows:

(*a*) The Time Charge for any injury resulting in the complete loss or complete loss of use of any member of the body shall be the number of days specified in the "Scale of Time Charges", 4.1. See also R5, R9, and R10.

(*b*) The Time Charge for any injury resulting in the loss of a part of a member or the permanent impairment of any function of any part of the body or part thereof shall be a percentage of the number of days specified in the "Scale of Time Charges", 4.1. The percentage to be used shall be the percentage loss or loss of use sustained by the injured worker, as determined by the local compensation authorities. See R5, R8, and R10.

3.5 Time Charge for Temporary Total Disability. The time charge for each temporary total disability shall be the total number of calendar days of disability, excluding the day on which the injury occurred and the day on which the employee returned or in the opinion of the doctor was able to return to work. See R6, R7, R9, and R11.

3.6 Time Charge for Temporary Partial Disability. The time charge for each temporary partial disability shall be the total number of calendar days of such disability multiplied by a factor not exceeding unity. Such factor shall be developed by the agency computing the time charge and shall be clearly stated. The total number of calendar days shall exclude the day on which the injury occurred and the day on which the employee returned, or in the opinion of the doctor was able to return, to his regular job.

3.7 Time Charge for First-Aid Cases. No methods are specified for determining time charges for first-aid cases. Any agency computing such time charges shall indicate the method used.

4. SCALE OF TIME CHARGES

4.1 Scale of Time Charges. The accompanying scale shall be used to determine the time charges in number of days as specified in 3.2, 3.3, 3.4*a*, and 3.4*b*.

Death	6,000
Permanent total disability	6,000
Arm, at or above elbow	4,500
Arm below elbow	3,600
Hand	3,000
Thumb	600
Any one finger	300
Two fingers, same hand	750
Three fingers, same hand	1,200
Four fingers, same hand	1,800
Thumb and one finger, same hand	1,200
Thumb and two fingers, same hand	1,500
Thumb and three fingers, same hand	2,000
Thumb and four fingers, same hand	2,400
Leg, at or above knee	4,500
Leg, below knee	3,000
Foot	2,400
Great toe or any two or more toes, same foot	300
Two great toes	600
One toe, other than great toe	See R9
One eye, loss of sight	1,800
Both eyes, loss of sight	6,000
One ear, loss of hearing	600
Both ears, loss of hearing	3,000

NOTE 1: Days shown in table are charged for complete dismemberment or complete loss of use of member. See 3.4*a*. For partial dismemberment or partial loss of use of member a percentage of these figures is charged, as explained in 3.4*b*.

NOTE 2: The charge for any permanent injury other than those specified in the scale shall be a percentage of the charge for permanent total disability corresponding to the ruling of the governing Workmen's Compensation Commission. See R9.

5. INJURY RATES

5.1 Frequency Rates. The frequency rates shall be the number of injuries per one million man-hours of exposure. See R12.

5.2 Severity Rate. The severity rate shall be the total time charges per one thousand man-hours of exposure. See R13.

5.3 General Comparability. In the interest of general comparability, every agency shall, as a minimum, compute frequency and severity rates based on classes of injuries as defined in 2.2 to 2.5 inclusive. Such rates shall be designated as "four-class" rates. The computation of additional rates based on classes of injuries as defined in 2.2 to 2.6 inclusive is recommended for such agencies as can secure dependable data on temporary partial disabilities. Such rates shall be designated as "five-class" rates and shall in all cases be in addition to "four-class" rates. Rates based on classes of injuries as defined in 2.2 to 2.7 inclusive, if computed, shall be designated as "six-class" rates.

6. RULINGS AND INTERPRETATIONS

R1 Basis of Reports. Any report made on any basis other than the all-inclusive basis provided in 1.1 shall state which groups or departments are included and which are excluded.

R2 Average Number of Employees. To obtain average, count names on payroll and salary roll of those at work for each day during period covered and divide the aggregate number of names by the number of working days. For example – 25 working days in November; aggregate number of names of those on payroll and salary roll and at work – 15,000. Divide 15,000 by 25 and the quotient 600 represents the average number of employees.

R3 Total Man-Hours Exposure. This figure should preferably be calculated from the time-clock, or foreman's card, or payroll records. If such records are not available the man-hours exposure should be estimated from the average number of employees. Assume a plant with 600 average number of employees working 50 hours per week for 52 weeks. The total man-hours exposure for the year, all employees, would be 600 x 50 x 52 or 1,560,000 man-hours.

R4 The Number of Injuries. The number of injuries, not the number of accidents, shall be recorded. For example, if ten employees are killed in one boiler explosion, ten injuries shall be recorded.

R5 Permanent Partial Disability. Every permanent partial disability as well as every death and permanent total disability shall be counted as an injury even though the injured does not lose any time from work.

R6 Method of Classifying Injuries. No matter at what time of day the employee is injured, if no permanent disability exists and if at the beginning of the next calendar day he is unable in the opinion of the doctor to perform his ordinary duties or the normal duties of some other regularly established job, *i.e.,* a job which is not set up solely to avoid counting the case as a temporary total disability, the injury shall be counted as a temporary total disability. On the other hand, if he is able to perform the normal duties of some other regularly established job, the injury shall be counted as a temporary partial disability.

R7 Example of Time Charge. Example 1: Employee is injured March 5 and returns March 22. Calendar days of disability — 16. Time charge — 16 days.

Example 2: Employee is injured April 2 and returns April 9. He again was unable to work on April 15 due to same injury and returns May 1. Calendar days of disability — 22. Time charge — 22 days.

R8 Permanent Impairment of Function. Example: If a complete loss of a hand is compensated by payment for 150 weeks, any impairment of function of the hand which is compensated by payment for 75 weeks shall rate as one-half of the complete loss of the hand or one-half of 3,000 days as specified in the "Scale of Time Charges", 4.1, or 1,500 days of disability. See also R10.

R9 Temporary Disability. Hernia, loss of teeth, and loss of any toe other than the great toe, are considered temporary disabilities only. For details see R6.

R10 Actual Time Lost. The actual time lost due to injuries specified in 3.2, 3.3, 3.4*a*, and 3.4*b*, SHALL NOT BE CHARGED.

R11 Calendar Period Charges. All injuries should preferably be charged to the calendar period in which they occurred. For example — man scratches hand on July 31. He reports for first aid on August 2, but on August 3 infection sets in, causing several days' disability. The injury should be charged to July 31. An exception may be made if the change affects an annual summary. Thus, if an injury in December, 1931, does not cause any disability until February, 1932, after the 1931 summary has been prepared, the work involved in changing the annual summary is hardly worth while, and it is better to consider the injury as occurring in 1932.

R12 Frequency Rate. To obtain the frequency rate multiply by 1,000,000 the total number of injuries and divide by the total man-hours of exposure.

Formula:

$$\text{Frequency Rate} = \frac{\text{Number of Injuries} \times 1{,}000{,}000}{\text{Number of Man-Hours of Exposure}}$$

R13 Severity Rate. To obtain the Severity Rate, multiply by 1,000 the total time charges in days and divide by the total man-hours of exposure.

Formula:

$$\text{Severity Rate} = \frac{\text{Total Time Charges in Days} \times 1{,}000}{\text{Number of Man-Hours of Exposure}}$$

R14 Workmen's Compensation Rulings. When in doubt as to whether or not to count a specific injury case, the decision shall be made in accordance with the ruling of the governing Workmen's Compensation Commission on this or similar cases.

R15 Ship Operations. For Ship Operations, compute man-hours of exposure by using eight (8) hours daily for each employee, regardless of actual length of time worked. Man-hours of exposure for Longshoremen should be computed from payroll.

R16 Ship Operations. For Ship Operations, count all injuries occurring on shipboard, or off ships while on duty. For injuries to Longshoremen, count only those cases occurring while on duty.

R17 Time Charges. If at the time rates are to be computed the time charge for any injury is not definitely determinable, the doctor shall estimate the time charge to be used.

APPENDIX II

Sound Slide Films

The following ten sound slide films consist of thirty-five millimeter film strips with twelve-inch two-side recordings; approximate running time twenty minutes. Produced by the National Safety Council in collaboration with the United States Department of Labor.

"Follow the Leader" — the responsibility of management and supervisors
"Cause and Cure" — methods of discovering and correcting accident causes
"Guard Duty" — principles of safeguarding against mechanical hazards
"Safety Is in Order" — importance of providing safe working conditions
"Brain Beats Brawn" — correct supervision in handling materials of all kinds
"Right Dress" — need of proper clothing and personal protective equipment
"Doctor's Orders" — provision for care of industrial injuries through first aid
"Principles and Interest" — maintaining employee interest in a safety program
"Stop, Look, and Listen" — an inspection committee for plant safety pictured at work
"Production With Safety" — controlling workers' acts through training and supervision

Note: The films listed above may be purchased for $37.50 from the National Safety Council, 20 North Wacker Drive, Chicago. Individual films may be borrowed from the local safety council in your city or from your insurance carrier.

The following films are recommended for the particular purposes indicated. They are all released through the National Safety Council.

"Invisible Red Ink" — shows the items that make up the cost of industrial injuries
"The Fall Guy" — illustrates the various types of falls and their prevention
"Grime Doesn't Pay" — shows the advantages of good housekeeping and how it may be maintained

"Open for Infection" — illustrates the importance of proper first aid
"Handle with Care" — illustrates the proper method of lifting and of handling materials
"Rules for Tools" — illustrates the proper method of use of tools and their care; also shows the results of improper use
"Fire" — dramatizes the common causes of fires and their prevention
"Woodworking Machinery" — illustrates the various hazards common to woodworking machinery and their correction
"Women and Machines" — stresses proper dress and hygiene for female employees.
"Eyes for Victory" — eye hazards and their control.
"Safe All Around" — home hazards and home safety.
"Are Your Feet Killing You" — pedestrian highway habits and hazards.

Special Sound Slide Films Produced by Other Agencies

"Off to the Right Start" — the right and wrong method of starting the new employee on the job; produced by the Vocafilm Corp., 424 Madison Avenue, New York, N. Y.
"The Eyes Have It" — an excellent film showing the various types of eye hazards, eye injuries, and their prevention; produced by the National Association for the Prevention of Blindness.
"Safety Pays" — one of a series of six films on foremen training; it stresses the advantages of persuasion rather than force; distributed by Modern Talking Picture Service Inc., 9 Rockefeller Plaza, New York, N. Y., and Ideal Pictures Inc., 28 East 8th Street, Chicago, Ill.
"Safely Yours" — a special appeal to female employees, stressing the importance of accident prevention; produced by R. M. McFarland and Associates, 520 N. Michigan Avenue, Chicago, Ill.
"To the Women" — for women only; a candid discussion of feminine problems and their relation to absenteeism; produced by Commercial Films, Inc., 1800 E. 30 Street, Cleveland, O.
"We're on the Spot" — a war-emergency appeal, covering a variety of hazards common to all plants; produced by Vision Education Productions, 509 Fifth Avenue, New York, N. Y.
"The Man Behind the Wheel" — safe operation of tractor-trailer trucks; produced by Fruehauf Trailer Co., Detroit, Mich.

Note: Your local safety council may secure these sound slides for you or will be able to suggest where they may be obtained. Projection equipment for use with these sound slides may be rented at a nominal cost.

REFERENCE:

National Safety Council, *A National Directory of Safety Films.*

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